Proceedings of The 9th European Conference on Games Based Learning

ECGBL 2015

Nord-Trondelag University College Steinkjer

Norway

8-9 October 2015

Edited by

Robin Munkvold and Line Kolås

Papers submitted to this conference have been double-blind peer reviewed before final acceptance to the conference. Initially, paper abstracts were read and selected by the conference panel for submission as possible papers for the conference. Many thanks to the reviewers who helped ensure the quality of the full papers.

This Booklet of abstracts and other conference materials is provided to conference participants for use at the conference.

Conference Proceedings

The Conference Proceedings is a book published with an ISBN and ISSN. The proceedings have been submitted to a number of accreditation, citation and indexing bodies including Thomson ISI Web of Science and Elsevier Scopus for indexing.

The Electronic version of the Conference Proceedings is available to download from **DROPBOX**. (**http://tinyurl.com/ECGBL2015**) Select Download and then Direct Download to access the Pdf file. Free download is available for conference participants for a period of 2 weeks after the conference.

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Preface

These proceedings represent the work of researchers participating in the 9th European Conference on Games-Based Learning, which is being hosted this year by Nord-Trondelag University College, Steinkjer, Norway, on the 8-9 October 2015.

The Conference has become a key platform for individuals to present their research findings, display their work in progress and discuss conceptual advances in many different areas and specialties within Games-Based Learning. It also offers the opportunity for like-minded individuals to meet, discuss and share knowledge.

ECGBL continues to evolve and develop, and the wide range of papers and topics will ensure an interesting two-day conference. In addition to the main streams of the conference, there are mini tracks focusing on the areas of the design of multiplayer/collaborative serious games, applied Games and gamification, the teacher's role in game-based learning, games for STEM (Science, Technology, Engineering, Mathematics) learning, assessment of digital game-based learning and pervasive and ubiquitous gaming for learning.

In addition to the presentations of research we are delighted to host the third year of the Serious Game competition, which provides an opportunity for educational game designers and creators to participate in the conference and demonstrate their game design and development skills in an international competition. This competition is again sponsored by SEGAN – Serious Games Network. With an initial submission of more than 60 games, 28 finalists will present their games at the conference. Prizes will be awarded to the games judged to demonstrate the best quality and originality of game play itself and the positioning and articulation of the game's contribution to the educational domain.

With an initial submission of 190 abstracts, after the double blind peer review process, there are75 research papers, 15 PhD research papers, 4 Non Academic papers and 8 work-in-progress papers published in these Conference Proceedings. These papers represent research from more than 40 countries, including Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Czech Republic, , Denmark, Finland, France, Germany, Greece, Hungary, Ireland, , Israel, , Italy, Japan, Malaysia, Norway, Portugal, Russia, Saudi Arabia, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan/ROC, The Netherlands, The Netherlands, United Arab Emirates, UK and USA

We hope that you have an enjoyable conference and that it fulfills your expectations.

Robin Munkvold and Line Kolås
October 2015

Conference Committee

ECGBL Conference Director

Professor Thomas M Connolly, University of the West of Scotland, UK

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Jordi Torrent, United Nations Alliance of Civilizations, NY, USA
Dr. Sylvester Arnab, Disruptive Media Learning Lab , Coventry University, UK
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Christian Reuter, Technische Universität Darmstadt, , Germany
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Dr. Stefan Göbel, Technische Universität Darmstadt, Germany
Assoc.Prof. Joze Rugeljuh, University of Ljubljana, Faculty of Education, Slovenia
Dr. Thorkild Hanghøj, Aalborg University, Denmark
Dr Daire O Broin, IT Carlow, Ireland
Dr Neil Peirce, Learnovate, Trinity College Dublin, Ireland

Committee Members

The 2014 conference programme committee consists of key people in the games based learning community, both from the UK and overseas. The following people have confirmed their participation:

Dr. Wilfried Admiraal (Leiden University, Leiden, The Netherlands); Dr. Minoo Alemi (Sharif University of Technology, Iran); Anissa All (iMinds-MICT-Ghent University, Belgi); Ana Almeida (Universidade de Coimbra, Portugal); ashish amresh (Arizona State University, United States); Dr. Daniel Aranda (Universitat Oberta de Catalunya, Spain); Dr. Sylvester Arnab (Coventry University, UK); Hans Christian Arnseth (University of Oslo in Norway , norway); Kristine Ask (Nord-Trøndelag University College, Steinkjer, Norway); Nikolaos Avouris (University of Patras, Greece); Isabel Azevedo (Instituto Superior de Engenharia do Porto (ISEP), Portugal); Jannicke Baalsrud Hauge (Bremer Institut f r Produktion und Logistik, Germany); Dr. Ana Barata (Instituto Superior de Engenharia do Porto (ISEP), Portugal); Dr. Wolmet Barendregt (Gothenburg University, department of applied IT, Sweden); Francesco Bellotti (University of Genoa, Italy); Mary Bendixen-Noe (Ohio State University, USA); Dr. Tobias Bevc (University of Augsburg, Germany); Dr. Bani Bhattacharya (IIT Kharagpur, India); Dr. Peter Blanchfield (School of Computer Science, University of Nottingham, UK); Dr. Melania Borit (UiT - The Arctic Univeristy of Norway (University of Troms), Norway); Natasha Boskic (The University of British Columbia, Canada); Dr. Rosa Maria Bottino (Istituto Tecnologie Didattiche - Consiglio nazionale Ricerche, Italy); Hadya Boufera (University Of Mascara, Algeria); Philip Bourke (Institute of Technology Carlo, Ireland); Dr. Liz Boyle (Univesity of the West of Scotland, UK); Dr Mairead Brady (Trinity College Dublin, Ireland); Dr. Tharrenos Bratitsis (University of Western Macedonia, Greece); Sara Brinch (Nord-Trøndelag University College, Steinkjer, Norway); Dr Cyril Brom (Charles University in Prague, Czech Republic); Prof. Anthony Brooks (Aalborg University, Denmark); Prof. David Brown (Nottingham Trent University, UK); Ellen Brox (Nord-Trøndelag University College, Steinkjer, Norway); Prof. Dr. Carsten Busch (University of Applied Sciences HTW-Berlin, Germany); Prof. Carlos Caldeira (University of Evora, Portugal); Dr. George Caridakis (University of the Aegean / NTUA, Greece); Dr. Thibault Carron (LIP6 - Paris, Université de Savoie, France, France); Dr. Rommert Casimir (Tilburg Uni-

Biographies

ECGBL Conference Director

Professor Thomas M Connolly is the original instigator of this conference in 2007, Thomas Connolly is a Professor in the School of Computing at the University of the West of Scotland, having managed the Department of Computing and Information Systems for several years. Thomas worked for over 15 years in industry as a Manager and Technical Director in international software houses before entering academia. His specialisms are games-based learning, online learning and database systems. He has developed three fully online MSc programmes and developed and leads the undergraduate BSc Computer Games Technology programme. He is co-author of the highly successful academic textbooks Database Systems (now in its 4th edition) and Database Solutions (in its 2nd edition). He is a reviewer for several international journals and has been on the committee for various international conferences. He is a member of CPHC (Council of Professors and Heads of Computing) and member of the Higher Education Academy.

Conference Chair

Robin Munkvold has his education from the field of information technology and has, for the last 12 years, been working within projects related to ICT and pedagogy. During these years, he has published a book titled "Online learning" and has been coauthor of many papers within the themes of ICT and pedagogy. Robin was central in the building of the curriculum Games and entertainment technology at the Nord-Trondelag University College and has the latest years been Program Director as well as Dean within the University College.

Programme Chair

Dr Line Kolås has her PhD in the field of information technology, focusing on e-learning and educational technology. She has since 1999 taken part in a number of national and international R&D projects. The projects have resulted in a variety of publications: scientific papers / articles, reports, newspaper chronicles etc. As associate professor at the Nord-Trondelag University College, Line is teaching at the study programmes of "ICT for teachers" and "Games and entertainment technology".

Keynote Speakers

Prof Alf Inge Wang is currently working at the department of computer and information science at the Norwegian University of Science and Technology (NTNU) where he teaches courses on programming, software architecture, mobile application development and game development. He received his PhD in software engineering in 2001. His research interests are game development, game concept development, computer support for mobile collaborative work, peer-to-peer computing, software architecture, and software engineering education. He has published more than 50 scientific papers including several papers on games and game technologies. He has also been organizing several conferences and workshops on computer games (Conference on Entertainment Systems, CoGames, etc) and is the chair of JoinGame (Norwegian resource network on game research and development). He is also responsible for the development of a research and education program within computer/video games at the university (NTNU). Has previous experience from game development on Commodore 64, Amiga, and Java game development. Alf is one of the main resources behind the development and implementation of the system Kahoot! (https://getkahoot.com/ - a game based classroom response system).

Dr David Williamson Shaffer is a Professor of Learning Science at the University of Wisconsin-Madison and a Game Scientist at the Wisconsin Center for Education Research, where his work focuses on using games and simulations to develop and assess complex thinking skills. His areas of expertise include game development, learning analytics, quantitative ethnography, localization and customization of learning technologies, and automated mentoring. Dr Shaffer's M.S. and Ph.D. are from the Media Laboratory at the Massachusetts Institute of Technology, and he has taught grades 4-12 in the United States and abroad, including two years working with the Asian Development Bank and US Peace Corps in Nepal. Dr. Shaffer was a 2008-2009 European Union Marie Curie Fellow and was awarded a 2014-15 Fellowship from the European Institute for Advanced Study.

Mini-track Chairs

Anissa All works as a junior researcher at IBBT-MICT (Ghent University). Since January 2013, Anissa is working on a PhD through an IWT grant (Flemish agency for Innovation by Science and Technology). In this PhD research, she will develop a standardized procedure to assess effectiveness of digital game-based learning aimed at cognitive learning outcomes.

Dr. Sylvester Arnab is a Senior Research Fellow, co-leading research at the Disruptive Media Learning Lab, building on his R&D experience at the Serious Games Institute, UK. His research focuses on the potential of games science (serious games, gamification) and the pervasive approach to learning and gaming. To date Sylvester has over 50 academic publications. He has also keynoted at events related to serious games, gamification and technology-enhanced learning. Sylvester is a founding member of the Serious Games Society (seriousgamessociety.org/) and Health 2.0 Birmingham. He is also involved in the UK satellite hub for Games for Health Europe.

Ricardo José Vieira Baptista is currently a Digital Media PhD Student at UT Austin|Portugal Program - International Collaboratory for Emerging Technologies, at University of Porto, researching training and certification in serious games and game-based learning. He is a researcher at INESC TEC and GILT with several participations in European projects and he developed Funchal 500, a Role Play Game (RPG) to celebrate the 500 years of the city of Funchal.

Dr Stefan Göbel holds a PhD in computer science and has long-term experience in Graphic Information Systems, Interactive Digital Storytelling, Edutainment applications and Serious Games. After five years work as researcher at Fraunhofer Institute for Computer Graphics, from 2002 to 2008 he was heading the Digital Storytelling group at the Computer Graphics Center in Darmstadt. In late 2008 he moved to TUD and is heading the prospering Serious Gaming group at the Multimedia Communications Lab.

Dr Thorkild Hanghøj is an Associate Professor at Aalborg University. He has more than 10 years of experience researching GBL in formal educational settings in number of countries. Thorkild has researched the important role of the teacher in relation to a broad range of different games such as The Power Game (ICT-supported debate game), Global Conflicts (serious game) and Minecraft (sandbox game). Moreover, he has also researched the use of Problem-Based Game Design in teacher education. He has recently received a large grant on the use of digital games and game-based teaching methods for the purpose of helping students in learning difficulties within the subjects Danish and Mathematics.

Silje H. Hommedal research focuses on perceptions of computer games in relation to gender. In her thesis that she defended in 2014, she focuses on how young women and men perceives different computer games as masculine or feminine and in what ways they use these perceptions in their construction of identity. The purpose of the research was to give knowledge on how gender and computer games are intertwined and affects each other. The doctoral thesis was written at The Department of Linguistic, Literary and Aesthetic Studies at the University of Bergen.

Dr Daire Ó Broin holds a Ph.D. in Computer Science from Trinity College Dublin, which focused on approaches to developing the conditions of flow. He has been a lecturer at IT Carlow since 2008, where he teaches on the Computer Games Development programme. His research interests include increasing engagement and intrinsic motivation in games and learning.

Dr Kimmo Oksanen is a project researcher at the Finnish Institute for Educational Research, University of Jyväskylä. His thesis was about supporting collaborative learning and evaluating learners' experiences in serious games. His current research interests include collaborative learning, game design, and game experience.

Prof. DI Dr Maja Pivec research interests are in the field of affective and emotional aspects of human-computer interaction, with emphasis on game design, game-based learning and innovative learning approaches, and different aspects of e-learning. She is editor and co-editor of four book publications in the area of innovative learning approaches and guest editor on several special journal issues on Game-Based Learning. Her research work is published and presented at more than 100 international conferences and publications.

Dr Neil Peirce holds a degree in Computer Science, a Masters in Multimedia Systems and a PhD from Trinity College Dublin (TCD). He is currently a research fellow in the Knowledge and Data Engineering Group at TCD. Neil's PhD research focused on the personalisation of learning experiences within educational video games and he is member of the Serious Games Society.

Christian Reuter is a PhD candidate at the Multimedia Communication Lab, TU Darmstadt. He is researching authoring support for creating multiplayer (serious) games, including the use of appropriate game design patterns based on player interactions, formal analysis to detect game design or implementation errors and rapid prototyping support.

Dr. Jože Rugelj is Associate Professor of Computer Science in Education at the University of Ljubljana and a head of the Chair for compuer science didcatics at the Faculty of Education. His main research areas include use of ICT in education, cognitive aspects of multimedia support for learning, serious games in education, and innovative approaches to teaching computer science. He has actively participated in 7 European and 4 national projects on e-learning and serious games. He published the results of his research activites in 11 papers published in international scientific journals, 58 papers in conference proceedings and 13 chapters in scientific monographies. His papers have been cited 41 times in Wos ans SCOPUS.

Jordi Torrent after obtaining a degree in Philosophy at the University of Barcelona, Mr. Torrent followed graduate studies in Paris at the Sorbonne University (Film Esthetics) and at the Ecole Pratique des Hautes Etudes (Anthropology Filmmaking). From 1985 to 1990 he was Media Curator at Exit Art, New York. He was Media Educator Consultant for the Department of Education of New York City, where Mr. Torrent created Media Literacy Education. From 2004-2008 he was co-director of "Overseas Conversations", a series of international conferences focusing on youth, media and education. He co-edited, among other publications, the book "Mapping Media Education Policies in the World", published by Columbia University. Currently Mr. Torrent manages the Media and Information Literacy initiatives at the United Nations Alliance of Civilizations (UNAOC).

Dr Carlos Vaz de Carvalho has a PhD in Information Systems and Technology. He is a Professor at the Engineering School of the Porto Polytechnic (ISEP) and the Director of the R&D group GILT - Graphics, Interaction and Learning Technologies until 2014. He was e-Learning Director (2001-2005) of ISEP and Director of the Distance Learning Unit of the Porto Polytechnic (1997-2000). He has published over 130 references on the subject including several books. He coordinated nine European Projects on the use of technology and games for learning.

Viktor Wendel is a PhD candidate at the Multimedia Communications Lab, Technische Universtität Darmstadt. His research interests include Game Mastering and automatic adaptation of collaborative multiplayer Serious Games based on player, learner, and interaction models and multiplayer Serious Game design. Further, he is an editor of ACM SIGMM Records.

Biographies of Presenting Authors

Azita Iliya Abdul Jabbar Prior to pursuing her PhD at Waterford Institute of Technology (WIT), Ireland, she was involved in eLearning project management and courseware design. Her interest in information and instructional design has led her to research and learn more about methods of teaching and learning, specifically in game-based learning.

Dr. Anna-Sofia Alklind Taylor studies the roles of instructors and how they can be facilitated within instructor-led game-based training environments. A core argument within her research is that serious games, as artefacts used for learning and training, cannot fully replace the instructors' tasks, but must rather be designed to facilitate the various activities of the instructors

Ana Cristina Almeida, Assistant Professor at the Faculty of Psychology and Educational Sciences, University of Coimbra (Portugal). Ana has had her PhD since 2004 in Educational Psychology (Cognition as Problem Solving). Research interests on promoting learning and development. Have some published and disseminated work. Coordinates a research and intervention platform based on games: Active Learning Community Project (CAAtivas).

Nafisa Awwal specialises in the design, development and implementation of web-based educational assessments, reporting and other forms of data collection tools. She is involved indeveloping system architecture for traditional and innovative, individual and collaborative assessments for students in multiple languages. Her research also includes data management, analysis, and item writing.

Sanna-Mari Äyrämö is a PhD candidate in the Department of Art and Culture Studies, University of Jyväskylä, Finland. Her main research interests concern narrative learning game design and the multidisciplinary field of narrative theories. In her current research, she focuses on the question of how to utilize narrative to support learning in computer games.

Tyler Baron is a full time PhD student at Arizona State University in Arizona in the United States. He has just completed his first year in the Simulation, Modeling and Cognitive Science PhD program there. His research interests are game based learning , serious games and simulations.

Dr. Bob Barrett is a full professor for the School of Business at the American Public University in Charles Town, West Virginia, USA. He lectures both nationally and internationally on the topics of Intellectual Capital, Human Capital, Knowledge Management, HRD Forensics, and Human Resource Management, Disabilities in the Workplace, e-Portfolios, and e-Learning.

Dr Matthew Bates Matthew is a lecturer in multimedia applications and computer-assisted learning at Nottingham Trent University in the UK. His research interests include the positioning of games-based learning applications which encourage collaborative learning through the construction of new materials.

Michael Bedek, **MSc.**, graduated from the University of Graz in 2009 in psychology. Since then, he has been working at the Knowledge Technologies Institute of the Graz University of Technology. Currently, he is working on his PhD thesis which is about the application of Formal Concept Analysis for learner modelling and adaptive recommender systems.

Björn Berg Marklund's research focuses on examining how the practical realities of formal educational settings change the way games need to be designed and developed in order to be useful as educational tools. For games to have educational value in formal educational settings, they need to be integrated into them, not superimposed on top of them.

Alexey Bezgodov, PhD, head of the Scientific Visualization Department at eScience Research Institute of ITMO University, Russia. The main interests are computer games technology, computer graphics and scientific visualization.

Natasha Boskic teaches graduate courses in the Master's of Educational Technology program. She obtained her PhD from the University of British Columbia, Vancouver. Her research was on ethics in alternate reality games. She also manages the Educational Technology Support unit in the Faculty of Education at UBC. Her interests are in creating engaging learning spaces.

Liz Boyle is a reader in psychology at the University of the West of Scotland. Recently her main research interests have been in learning and motivation in e-learning, digital games and social media where she has published journal and conference papers, edited books and book chapters. She is currently project coordinator of the Erasmus + YOUTHYES project.

Cyril Brom is an assistant professor at Faculty of Mathematics and Physics of Charles University in Prague. His research interest is in serious games, modelling behaviour and episodic memory of virtual human-like characters, in level of detail AI, and in computational biology.

Sophie Callies is a PhD student in cognitive computer sciences at University of Québec at Montréal (UQAM), Canada. Her thesis is in the field of serious games and their design. Her research interests are serious games, video games, game design, educational design, gamification, and cognitive sciences.

Tracey Cassells graduated from IT Carlow with a B.Sc(Hons) in Computer Games Development and is currently enrolled as a Masters student. Her research interests are in gamification and the effect of game elements on student engagement.

Fabio Chiarello is a Physicist/researcher, IFN-CNR Rome (Institute for Photonics and Nanotechnologies of Italian National Research Council). Scientific interests: superconducting devices and detectors, quantum computing and macroscopic quantum phenomena, terahertz technologies, micro and nano-systems. Expertise: devices design, ultra low noise and low temperature electric measurements, simulations and modeling, data analysis. Active in scientific dissemination with conferences, development of didactic board-games and exhibitions/laboratories for science festivals, author of a book (Italian) on Quantum Mechanics and Quantum Computing for general public.

Ming-Hung Chu is a master student in the Institute of Creative Industries Design at National Cheng Kung University. He is an experienced teacher in industrial high school for 28 years. His expertise is in engineering graphics, computer 3-D modeling, creative design, new he design a serious game help students to master the orthographic projection learning.

Constantos Elias holds a Diploma in Electrical and Electronic Engineering from NTUA, Athens. Over 25 years experience in top Greek Information Technology companies, accustomed in multicultural / multinational environments, managing both commercial and research projects. Is recently involved in Business Process Management projects and development / deployment of custom gamification projects for international clients.

Larry J. Crockett is Profess of Computer Science at Augsburg College, Minneapolis, MN, USA. He took his Ph.D. from the University of Minnesota and has published three books, including Universal Assembly Language and The Turing Test and the Frame Problem. He directed the Honors Program for 16 years. Currently he teaches "Game Programming on the Web" as a senior experimental course.

Helga Dis IsfoldSigurdardottir received B.A. in social Anthropology, M.A. in Educational Program Evaluation from The University of Iceland. Currently a PhD candidate/research fellow at Nord-Trøndelag University College in Steinkjer, Norway and The Norwegian University of Science and Technology in Trondheim, her research focus is DGBL with a Science and Technology Studies approach.

Viktor Dobrovolný is a student of New Media Studies atFaculty of Arts of Charles University in Prague. His main study interestsare serious games and structure and transfer of knowledge. He assists in research on learning effects of serious games since 2012.

Ronald Dyer Lecturer, Project Management with experience across financial service, education, agriculture and energy focused organizational transformation initiatives. Worked on IT integration projects at Goldman Sachs, Citi-Bank and Inter-American Development Bank. Research includes individual/institutional performance utilizing technology innovation. Attended Grenoble Ecole de Management, France, researching Serious Games for Technology, Innovation & Change towards Doctorate in Business Administration. MBA in Project Management Henley Graduate School of Business University of Reading, UK;undergraduate degree Wilfrid Laurier University, Canada in Business Administration.

Stine Ejsing-Duun is interested in the relation between technology, perception and cognition. Her ambition is to describe how technologies allow us to transcend ourselves. Her research has been connected to games, play and playful processes in various areas. Her present studies are within the fields of learning and art.

Dr Panagiotis Fotaris is a lecturer at University of East London and Programme Leader of the BSc (Hons) in Digital Media Design. His research interests include gamification, learning analytics, and Technology Enhanced Learning. He is also a member of the emotionUX usability lab team who explores user experiences from cognitive, emotional and affective perspectives.

Laura Freina is a research fellow at the Italian National Research Council where she is involved in the design and development of solutions to support personal independence for people with mild intellectual disabilities. In the last months, she has developed a Virtual Reality based Serious Game in support of the acquisition of basic spatial skills.

Regina Friess is Professor for Media Conception, since 2011, at the Digital Media Department of the University of Furtwangen, Germany. Before she was Lecturer for interactive media at the University of Arts in Berlin. She worked as graphic designer, 3D-modeler and as concept developer since 1993. Her academic interest focusses on interactive narration in audiovisual media.

Toru Fujimoto is an assistant professor at the Center for Research and Development of Higher Education, The University of Tokyo. He completed his graduate study at the Pennsylvania State University (Ph.D. in Instructional Systems). His research focus is on the design of learning environments using digital games and social media.

Andrea Gauthier is a biomedical communicatorfrom Toronto,Canada. Her education includes a bachelor of applied arts in Scientific Illustration and a Master of Science in Biomedical Communications. She is pursuing a PhD in medical sciences at the University of Toronto where she is investigating how the game design influences students' understanding of molecular systems.

Valerie Priscilla Goby, PhD, is a Professor at the College of Business, Zayed University, Dubai, UAE. She has published widely in business and education related areas, is on the editorial board of Journal of Business and Technical Communication, and Business and Professional Communication Quarterly, and deputy editor of Learning and Teaching in Higher Education: Gulf Perspectives.

Anthi Gousiou is a PhD candidate at the Department of Cultural Technology and Communication, University of the Aegean. She holds a Bsc degree in Computer Science and a Msc in Computer Science from National and Kapodistrian University of Athens, Greece. Her research interests include game-based learning, gamification, use of ICT in education. She works as a Computer Science teacher in Secondary Education.

Jacob Habgood has a decade of experience working in the UK videogame industry and is now Senior Lecturer in Game Development at Sheffield Hallam University where he teaches PlayStation 4 programming. His research interests focus on effectively harnessing the motivational power of games for learning, as well as the affective motivational components of digital games themselves.

Paul Hollins is Director of the institute of Educational Cybernetics at the University of Bolton. Paul has been undertaking research into digital games and Learning for over a decade and has published extensively in the domain . Prior to returning to academia Paul worked for an International games Publisher responsible for licensing.

Ellen Houmøller is a master of Art in Modern Culture, Copenhagen Universityand Master in Lifelong learning and Adult Education. Aarhus University. Lecturer, Lillebaelt Academy for Professional Higher Education, department of It and Media, Odense, Denmark. I have special focus on e-learning and lifelong learning. I have done several courses in various subjects within strategic communication and management.

Robyn Hromek works as an educational psychologist in Sydney schools Australia and is an Honorary Associate of The University of Sydney. She has a Masters Degree in Educational Psychology. Robyn has developed a series of psycho-educational boardgames to teach social and emotional skills to young people and is currently writing therapeutic comics.

Dr. Hans Hummel is associate professor at the Welten institute of the Open University of the Netherlands (OUNL). Hans held the Chair on "Workplace learning and ICT" (2009-2014) at NHL University of Applied Science, lead the EMERGO project developing an approach and toolkit for serious games (Comenius Award, 2008), and acted as (co) author of 100+ refereed articles.

Sharon Hu has a longstanding interest in developing best practices for the hybrid learning environment and the use of multimedia in teaching and learning. Some projects Sharon has worked on include the use of collaborative annotation in online lecture videos, the development of a MOOC, and the inclusion of gamification to motivate and engage students

Jennifer Jenson is Professor of Pedagogy and Technology in the Faculty of Education and Director of the Institute for Research on Learning Technologies at York University, Canada. She has published widely on education, technology, gender, design and development of digital games, and technology policies and policy practices in K-12 schooling.

Bjarki Þór Jónsson got his Masters in Digital Games: Theory and Design from Brunel University, London. He has been developing new video game related courses in The Comprehensive College/Comprehensive Secondary School at Ármúli and The Tröllaskagi Upper-Secondary School where he currently is a teacher. Bjarki was a jury member for the Nordic Game Awards in 2014 and 2015.

Ronit Kampf, Ph.D., is a lecturer in the Department of Communication and the Program in Research of Child and Youth Culture at Tel-AvivUniversity. Her research interests focus on serious games and learning, particularly in the context of the Israeli-Palestinian conflict. She is a member of the Games for Peace initiative.

Aous Karoui is a PhD student at the University of Maine since October 2014. He received his master in "studying complex systems: natural and artificial cognition" from *EcolePratique des Hautes Etudes*in Parisin June 2014. His research interests are related to mobile technology, serious games and Human Machine Interaction.

Wijnand Kieft is teacher at a secondary vocational training centre with 5000 students. As coordinator at the Foundation for Practice-based Learning (SPL) in Amersfoort he is responsible for the developing of career building programs, programs for business skills and higher education preparation. His master thesis dealt with the use of the serious game Future = Now.

Andreas Lieberoth is an appliedgame psychology researcherat the Interacting Minds Centre, Aarhus University, and an associated researcher and game designer at the Centre for Community Driven Research (CODER). His Ph.D. was in cognitive and educational psychology. He has (co-)designed several games, both digital and analogue. His academic work centers on the social and cognitive psychology of gaming, especially in the context of player psychometrics, game based learning, citizen cyberscience and experimental studies of gamification.

Jordi Linares-Pellicer has a PhD in Computer Graphics. And is a lecturer and researcher at Universitat Politècnica de València in Spain. Currently leader of VertexLit research group focused on interactive technologies, games, serious games, virtual and augmented reality.

Gerrit Lochmann, has a master's degree in computer science and is working as a computer scientist at the Institute for Computational Visualistics of the University of Koblenz, Germany. His research interests cover the field of interaction within virtual environments as well as optimization methods for real time computer graphics.

Heide Lukosch is an Assistant Professor, Delft University of Technology, part of Multi-Actor Systems Department. Research focused on analyzing how organizations and their members, understood as interacting systems in a modern, complex society, use different media like games, simulations and virtual environmentsto enhance awareness/communication processes. PhD from Fernuniversität Hagen, Germany (study in media sociology). Interested in link between social/technical perspective on complex systems.

Rikke Magnussen is an associate professor at ResearchLab: ICT and Design for Learning, Department of Communication, Aalborg University. Her main research interest is how intelligent or game-based technology can open for new types of collaborative science practice and innovation processes to change science education in school and science learning in in-formal settings outside school.

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Serious Game Framework Focusing on Industrial Training: Application to Steel Industry

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Abstract: Serious games are growing more and more in the context of lifelong training and initial education. They cover several areas (human science, engineering science, life science, ...) that are used for industrial or academic purposes. However, some fields induce specific issues. Thus, in the industrial area, the constraints inherent to the activity impact the development of a scenario and implementation of a serious gaming environment. Indeed, the objective of the industry training must both lead to the acquisition of knowledge and the transfer of skills. Moreover, the actual validation of these skills is paramount especially if their uses are located on an industrial site, where there are often risks associated with the security of persons and equipment. In many industries, some regulatory constraints impose an obligation of means for the training of staff. In the sector of production, the proliferation of interim requires inevitably targeted training. Finally, it should be noted that even for permanent staff, alternation and fragmentation of training periods seriously complicate the deep learning task. Finally, we can wonder if the serious game can bring relevant answers to specific problems of training in an industrial context? This article offers some answers to this question. Thus, in this work, we propose a serious game scripting framework adapted to the industrial context. This scripting framework is structured around two approaches: the first defines a global framework for scheduling a fun or playful scenario. Moreover, this framework allows to take into account the phases of availability of learners while maintaining motivation. The second approach defines an immersive framework for validating acquired and security compliance that is based on two complementary purposes: Use of alternate observation activities (games / real) and an immersive simulation (Virtual Reality) for security. In partnership with a company in the steel industry, we have developed a prototype of serious game in order to implement this scripting framework. The prototype is based on a generic game platform, on a tablet with use of RFID tag, and with an immersive virtual reality Head-Mounted-Display (HMD type Oculus®). In this article we will present the actions realized in the context of a professional activity related to the manipulation of a bridge crane.

Keywords: serious games, formatting, virtual reality, interaction

1. Introduction

Continuous training methods are different from methods used in initial training. However, many pedagogical innovations are used in both contexts. Serious games are a good example of a new pedagogical approach that we find in initial training as well as in enterprises. Their principal objective is to increase the attention of learners using playful workings (Alvarez & Djaouti, 2010).

Therefore, even in professional training context, motivation remains a real engine for learning (Sauvé et al., 2007). The game enhances learning through personal engagement and emotions that it generates : "motivation creates favourable conditions for learning having positive impact on cognitive learning, emotional and psychomotor (...), the game motivates learner, structures and consolidates knowledge, it favours problems solving and influences behaviour"

For many, the training context in enterprises induces new constraints and supplementary difficulties. Those difficulties that we will specify in the next paragraph can be offset by an adapted approach of a serious game construction. Therefore, the proposed approach in this article is mainly based on immersive effects of 3D serious games in order to be able to avoid or to overcome the associated constraints or difficulties.

2. Serious games and training in enterprise

Continuous training of staff throughout their professional activities is an important issue for enterprises due to many reasons. First of all, trained workers can thus adapt themselves easily and increase their polyvalence within the company. It is also one of many factors that allows them to improve their employability. However, in industrial companies, technologies evolution (processes, products, production machines) requires the implementation of adapted trainings for all of concerned personal.

Our work is concentrated in industrial sector. In this context, we can identify specific issues.

- Availability: Trainings must be performed within work hours, but the staff availability is often constrained by production needs or by company activities. In this case, the lack of availability implies splitting training sessions.
- Heterogeneity: In industrial context, learners in the context of companies have usually different levels and initial trainings. This generates a strong heterogeneity.
- Validation of know-how: The training in the industrial environment can be truthfully linked to the direct or indirect know-how (use of a special production machine). The use of specialized equipments requires effective validation of expertise. Besides in certain industrial activities, the use of specific equipments can be subject to regulatory constraints.
- Security: Some industrial equipment may be dangerous. It is necessary to take into account safety precautions or teach specific security guidelines.

In this article, we propose a "Game centric" approach that can take into account those different problematic issues. Serious games are software applications that use playful assets such as competition, rewards or simply curiosity to catalyze the learners' attention and facilitate their learning (Dondlinger, 2007). So they are often used to increase the motivation of learning sessions in education (Kelle, 2011). The same approach is used in companies to offer lifelong training for employees.

Among the many serious games developed in recent years we can for example mention, Laboratorium of Epidemiology (Ney, 2010), used to train students in medical fields and to enable them to find solutions to avoid the spread of nosocomial infections in hospitals, Prog&Play (Muratet, 2012), used to teach the basics of computer programming and many other serious games (Michaud, 2008), designed to teach business skills in many fields such as financial transaction mechanisms, handling and use of complex machines, industrial productivity, data security ...

3. Approach for serious games in the industrial environments

In this paper, we propose a specific approach to build up games allowing to solve the previously mentioned problems. The following table (Table 1) shows the potential improvements of a serious game considering the industrial constraints.

Table 1: benefits of a serious game in an industrial context

Identified constraints	serious games benefits
the personnel's availability	maintain the motivational aspect despite of the length of the traineeship
sectioning and partitioning the learning process	
heterogeneity among students	able to create alternatives or specific quests in a playful scenario
knowledge validation	immersion and simulator integration

Moreover, an important element to consider while creating a serious game scenario is the respect of the balance established between playful and serious/learning aspects. Several debates are held in the community at this level (Ritterfeld, 2009), certain authors emphasized the playful aspects for motivational reasons (Prensky, 2001), others promote educational aspects by slightly "gameful" and generally significant (Michael, 2006). In the industrial context, this balance is particularly important for the serious game acceptance when key issues are concerned. Overall, the proposed constructional approach is based on:

- Defining the sessions granularity
- Using immersive aspects

3.1 Game sequencing and granularity

In the different experiments that we already carried out, the game time was based on deadlines set by teachers (Pernelle et al 2012). In the context of enterprise training, time is basically defined as a critical resource because of the restricted availability of staff on a long duration. Therefore, we did define a module representing the minimal game granularity as an indivisible sequence of play with the following properties:

- duration is predetermined and should be known in advance
- a module must allow to acquire a measurable or evaluable skill or know-how or it must validate a skill or know-how

For example, in the industrial experiment that we present at the end of this article, the game granularity is fixed to period of 30 minutes which was acceptable for the company.

3.2 Validation context of acquired knowledge

The urgent need of assets' validation represents a key point in the industrial context. In fact, the skills and expertise can be submitted to either regulatory or security constraints (Environment hazardous, heavy equipment, special machine, ...). Knowledge validation is performed by explicit evaluation mechanism (quizzes, MCQ, …) that are generally and essentially theoretical. Nevertheless, as part of this paper, we also propose an extremely immersive context of serious game enabling implicit assessment following two methods:

- A validation based on uses and traces
- A validation based on simulation

The assessment based on uses and traces permits to isolate the player's actions or interactions that are able to intervene appropriately as practical factor to induce knowledge acquirement. The system implemented uses all significant traces: game traces (interactions, movement, etc.) and business activity traces (thanks to traced business information systems). The aim of these traces is to improve the user monitoring for individual actions but also and especially during interactions and business activity (Marty et al 2012).

Moreover, in industrial context, it is important to be as close as possible to reality therefore we focused on simulation. The simulation allows representing the real behaviour of a process or equipment. In our context of serious games, they are able to simulate as faithfully as possible, the behaviour of industrial equipment. To do this, we should associate serious game with massive immersion to improve the results.

For immersion and interaction we have to appeal to virtual reality (VR). VR has been defined by the concept of dimension I^3 (Interaction-Immersion-Imagination) (Burdea et al 1993). VR requires some human-machine interaction between interactive virtual environments systems and users. We can use different type of sensory-motors to interact with virtual environments (VE). Basically, we have used the visual rendering and 3D displays system to submerge operators in the virtual world. It provides the ability to view a virtual environment and interact with it in real time. VR has used typically in design and manufacturing (Brey 2008).

The most important role of virtual reality in serious game is the engagement of player's mind via sensory simulation (Jeffries 2005) (Galarneau 2007). With virtual reality techniques, we can provide methods for increasing the presence of player in the virtual environment. This presence allows the player to better be aware of his environment and to project their natural interactions. Most applications of virtual reality rely on two indispensable pillars: 3D visualization that allows the operator to immerse into the scene and interactions that are generally used to give players a feeling of presence in the virtual environment by manipulating virtual objects. So if we have the notion of presence and interaction inside the virtual world, we can develop simulations based on a visual, interactive feedback.

4. Application context to industrial enterprises

4.1 Context and scenario

The context of our application is as part of steel enterprises. It is essential for this company to form the permanent and temporary staff for handling steel plates with a bridge crane. Initially, such training consisted in one presentation session, followed by an observation session of 10 days.

As part of the implementation of our serious games, we re-organized the training into 20 sessions of 30 minute. Each sequence is built on the principles set out in subsection 3.1. The following figure (Fig.1) shows the four blocks (localisation, resources and scenarization) of a session.

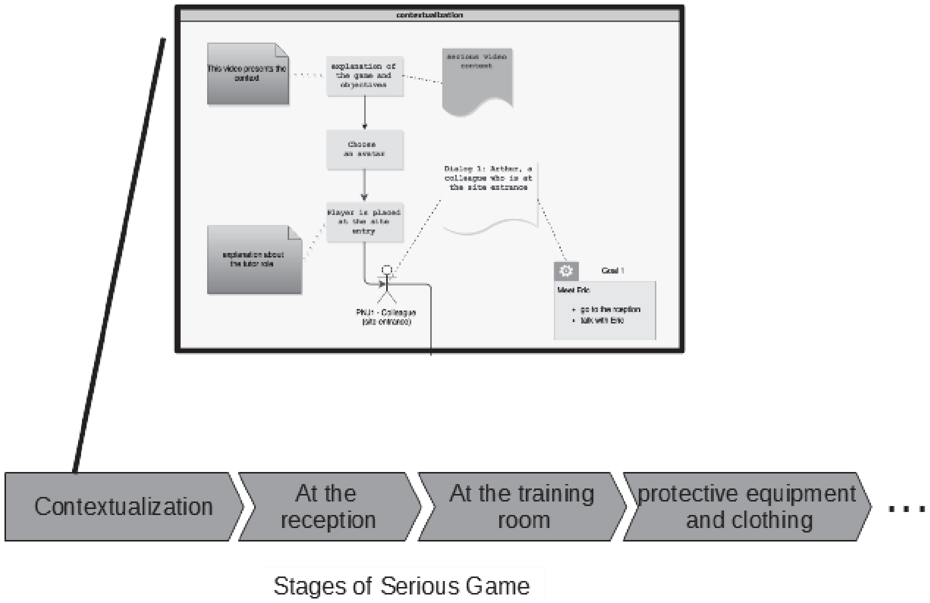

Figure 1: Extract of playful scenario

The serious game is built on the Learning Adventure environment which is described in the following paragraph. This serious game is a 3D game MMORPG type. Besides the construction process of sequences, we add some very immersive activities through virtual reality (paragraph 3.2) (Fig.10). Finally, the player will use a 3D game environment and a virtual reality environment.

4.2 Game environment

Learning Adventure (L.A.) is a generic Serious Game environment based on a role-play approach (Baptista et al 2008). The players, represented by their own avatars, can move through the environment, performing a sequence of sub activities in order to acquire knowledge. This environment is generic in the sense that the teacher can adapt the environment before the session by setting pre-requisites between sub activities and by providing different resources (documents, videos, quizzes) linked to the course. The Non-Playable Characters (NPCs) give objectives and we have modeled an industrial site from the actual architectural plans in order to ensure the players' immersion, especially for the employees of the company. The following figure (Figure 2) shows the L.A. interface composed of a menu, a mini-map indicating the objectives and indicators.

The following figure (Figure 3) illustrates the recovery mechanism for the pedagogical resources (document, video, test): the objects are stored in the player's "bag" so it can be accessed at any time.

The following figure (Figure 4) shows the player in the hydraulic press in front of the modeled bridge crane just before accessing to the virtual reality part.

Figure 2: Example of interaction in the new version of L.A.

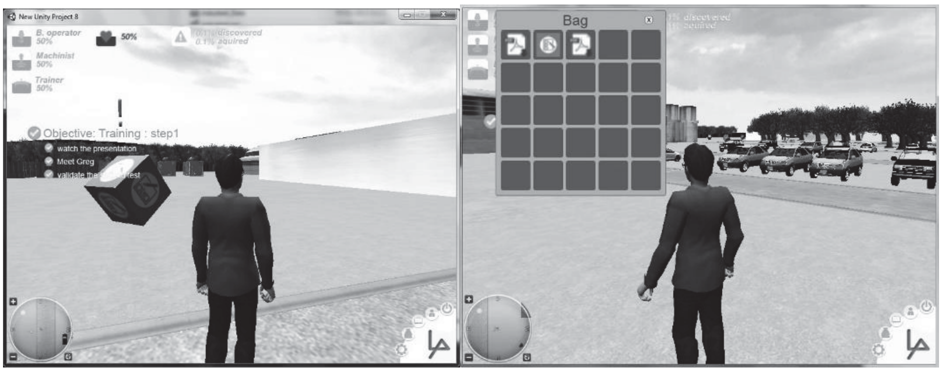

Figure 3: Example of interaction in L.A.

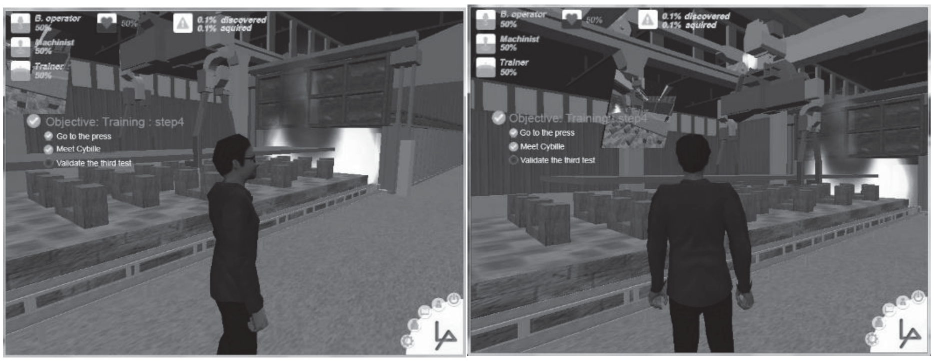

Figure 4: The player in the hydraulic press building

4.3 Illustration with the modelling and use of a virtual environment

The virtual environment is an artificial environment that exists only in the numerical model and can present a real or imaginary environment or a mixed version between the two. Users (real), represented by their avatars (user selected his own virtual appearance) can interact with the virtual environment according to well-defined laws.

4.3.1 Modelling and visualisation

Before modelling, a tour of the factory was carried out for taking dimensions of objects and to understand the culture of the profession of a bridge operator and straighten of sheets. We took photos and videos that serve as reference for modelling the scene.

First, we identify the main parts of the mechanisms that exist in the plant. We noted that there were three main parts: the press machine, the bridge (for transport) and the hall of the plant.

Second, the objects that belong to the same equivalence class were modelled in a single model. It avoids making assembly of the parts that are not important in the 3D software (CATIA®). Furthermore, the standard elements including screws, nuts or seals are not modelled because their size is negligible compared to the other elements. After finishing to model parts in CATIA, we assemble them using the link graph. So we have a part tree that shows the main parts with its subparts. This tree must be strictly kept because it is important for the next step: make the relevant animations in the game engine.

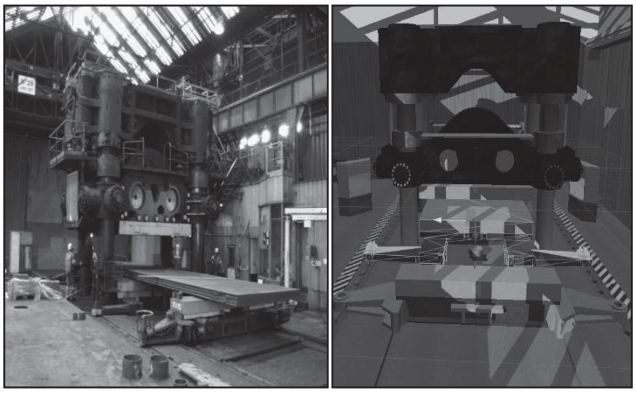

Figure 5: 3D modelling of the hydraulic press

Figure 6: 3D modelling of the bridge crane

4.3.2 Data transfer and model integration in game engine

The data transfer problem between the computer-assisted design software and the game engine (Unity) is a known problem. Several approaches are available and diagrams are defined to convert data without any loss of information but concretely, this loss is always present and approaches are specific to the context of a definite use.

In our context of use, the virtual environment is modeled with CATIA (CAD type modeling software). Then a conversion to the FBX format is needed for use in Unity. The goal is to move from CAD to Unity without data loss and effectively without faces duplication problems and finally without loss of materials. We tried several combinations and we set an optimal path for these types of conversions as shown in the figure 7.

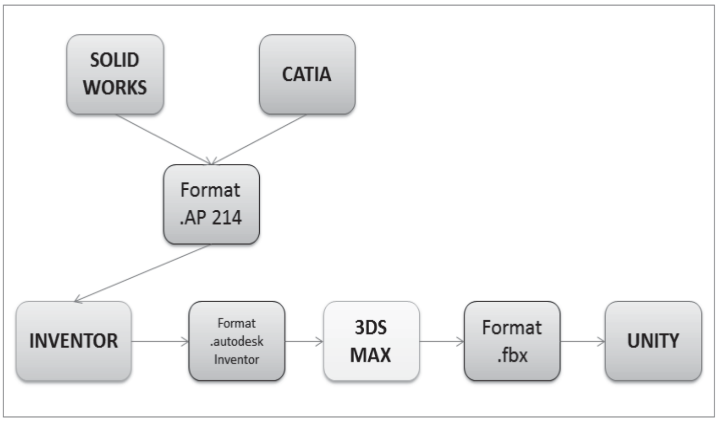

Figure 7: Optimal chain for 3D data conversion.

4.3.3 Interaction with virtual environments

The 3D visualization device will be a HMD type Oculus Rift. On a recent computer with 1080p resolution, we can have a display stream with a respectable frame rate (> 30 frames/s). For more complex scenes with a lot of interactions, we can possibly reduce the rate of frames per second. On such device and thanks to a gyroscope, we can detect the orientation of the head. With head orientation, we can perform a head tracking in real time. It is thus possible to obtain a 360° vision of the scene.

Figure 8: Using a 3D visualization device (Oculus Rift)

For operator tracking, we use the Kinect® motion-type V2 sensor, which allows to track the operator in an area of half a circle of 3 meters radius. This sensor detects the person in front of the Kinect and makes a skeletonization of the individual, identifies the set of transformations and movements produced by the latter and projects them into the virtual environment. With Kinect, we track the entire body except the head, which is tracked by the gyroscope of the oculus. In our case, the Kinect V2 can provide an acceptable level of accuracy on movements tracking but it revealed sometimes unstable concerning small movements and occasionally the hands were jumping in all directions… Luckily, in our context, the accuracy is not crucial. Our goal was to strengthen the physical presence of the operator in the virtual environment and thus to provide a way to achieve know-how exercises with the most effective manner in terms of skills transfer.

Figure 9: Using a Kinect to detect gestures for commanding lifting devices

The aim of the game is to give the employees another kind of formation technics. This approach does not require direct interaction with virtual elements. However tangible interfaces were created. Tangible interfaces are represented by the control box to manipulate the deck and the press dashboard. The expected interaction is simply based on the laws of normal physics. We categorize the needed interactions in two categories:

- Static interactions between virtual elements
- Dynamic Interactions between virtual elements or avatars (NPC).

For static interactions, we do not define constraints or physical laws. This type of interaction is the simplest. These interactions are typically used in remote parts of the stage where we have a visual feedback without having to visit these places.

Dynamic interactions are more complex: For instance, interactions between the sheet and the bridge are based on the basic principles of physics (rigid-body for the steel sheets and the bridge). The bridge must carry the sheet from position A to another position B. This operation and its movements during the bridge is submitted under the pseudo-physical effect when we increase the effect of "pseudo-balan" (balance effect). Using physics allows us both to optimize the program and maintain an acceptable frame per second (FPS) rate and secondly to exaggerate and/or control this phenomenon for learning purposes. The second kind of interaction is the interaction between two sheets. Interactions between sheets are not very important in this game because the operator will carry and move a single sheet and shall put it on the press or in the oven or on another sheet. For the moment, we chose to automatically activate the appearance of shims for storage sheets but another learning session will be dedicated to this expertise (the aim is to correct the possible binding of a sheet thanks to a good choice and placement of shims).

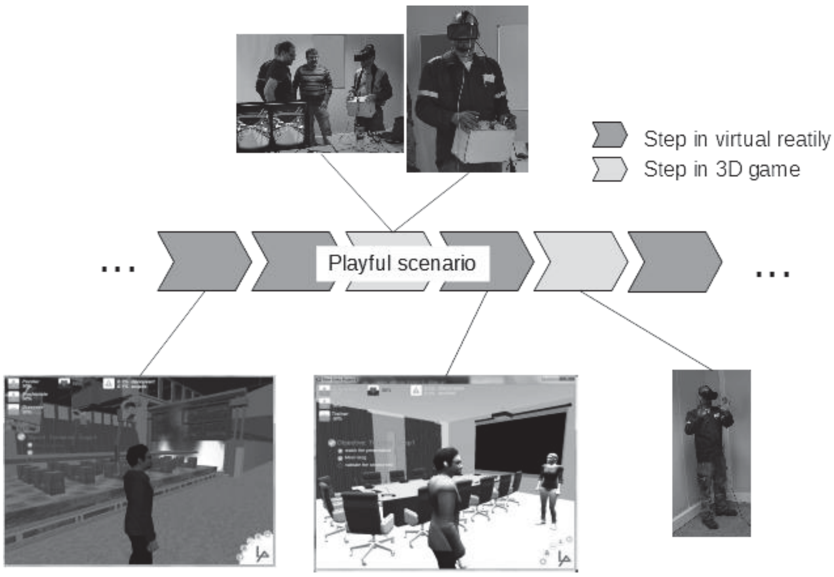

Figure 10: playful scenario with game steps and virtual reality steps

5. Conclusion

In this article, we showed the interest of serious games in the field of professional training to tackle specific issues: availibility, safety, know-how assessment and heterogeneity. They maintain the same motivation even if the training is fragmented due to the unavailability of staff. Moreover, it is very useful for some dangerous phases to simulate a process or an equipment (here a 2t hydraulic press and a bridge crane for massive steel sheets). To achieve this goal, we used innovative virtual reality technologies integrated into a serious gaming environment to be able to evaluate know-how with simulation aspect. Virtual reality can be used to increase the level of immersion, the notion of presence in the virtual environment and isolates/protects the operator. We add some sway effect to attract the attention of players and to validate his expertisewith also use tangible interfaces (Bridge Control levers we could spend handling skills).

We also show that the tracking is very important first, to increase the level of presence and the interactions level and second, to be able to assess the learning progression.

However, we observe sometimes some difficulties concerning the effective tracking: if the tracking is not stable it is preferable to remove it from the scene and to replace it with a simple navigation methods (buttons mouse and keyboard...). As a matter of fact, if the tracking is not stable, it may return contradictories information that can disrupt the field of vision and may reduce the immersion level and the quality of learning.

Among the current perpectives, it is possible to improve two aspects: the first concerns the immersion by adding a multi-dimensional sound environment. the second concerns the integration Game/Virtual Reality which could be reinforced in particular by a common trace generation and the Exchange of information or indicators in both environments.

The last part but not the least is the possibility to make experiment some specific works and skills to other types of employees of the company in order to facilit exchanges and understanding about a particular profession.

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Technology Integration in Multiplayer Game Design

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Abstract: Online multiplayer educational games can be designed to promote collaboration and assess abilities of students through their responses or actions within the game environment. This paper describes the design and integration process for such games, prototypes of which have been developed as part of the ATC21S™ research study by the University of Melbourne. HTML5 has been used in preference to other available technologies in creating the games to provide a consistent experience for students across all browsers, platforms, and devices. The multiplayer component of the games was supported with the use of the Web Socket application which enabled the communication protocol between the client and server to be established. Canvas is used to create all animations and game objects. The paper will describe justification for the use of additional technologies to facilitate the game flow and a positive user experience.

Keywords: game design, collaborative, HTML5, canvas, web socket

1. Introduction

The games discussed in this paper were designed as part of the Assessment and Teaching of 21st Century Skills (ATC21S™) study. The games focus on collaborative problem solving; some of games were originally developed by Zoanetti (2010) for single student use in computer based problem solving. The development of online games for learning has progressed rapidly in recent years. Marchetti (2014) advocates the need for digital games that can be altered to allow students to play and express themselves during their learning. For example, the design and integration of the application SimApps within GameScapes is described by Amresh (2014) and presents a novel method of integrating rich narrative based storytelling within short repetitive game play procedure to encourage student learning and improve retention.

Due to serve multiple purposes, web based games made by developers are currently highly interactive and for this developers need to include animations, video stream, music and other forms of multimedia into web based games. Until now there have been limited tools available for use, such as Flash or Silverlight, Flex or JavaScript. However, these options can take a lot of time to integrate and increase the complexity of development. With the emergence of HTML5 it is possible to embed video and audio, high quality drawings, charts and animation and other rich content without using any plugins and third party programs as the functionality is built into the browser. Canvas, an element of HTML5, has been used to enable interactive dynamic bitmapping, drawing, animation, and simulations. The Canvas element allows for an easy transition from plain to dynamic web pages that are applicable to mobile devices, perhaps why it is popular with developers. In Crockett's (2014) paper the use of HTML5 with Canvas for game development with user impression is described in detail, as it has advantages over using Flash applications. Due to the benefits outlined above HTML5 was the application of choice for development of online educational games for the ATC21S™ study in order to provide a consistent experience for students across all browsers, platforms, and devices.

The games designed in this study were multiplayer allowing two students' to interact by sharing resources and communicate through an embedded chat box. This facility can be used to assess abilities of students through their responses or actions within the game environment. Multiplayer games can use networking technology to allow game play from separate locations, and even over a greater distance. The multiplayer component of the games is supported by HTML5 and Web Socket, which dictates the full communication network that operates through a single socket over the Web. To integrate multiplayer use Masuch's (2005) paper has a focus on teaching collaborative game design within a specific platform referred to as OpenCroquet. A general outline of the game design process, the structure of digital games and the requirements for the use of OpenCroquet as a platform for collaborative game design is described.

Selected technologies were used in ATC21S™ to facilitate game flow and a positive user experience. The design and integration process for this is described in this paper.

2. Game design

2.1 Platform

The games, or tasks, were intended for international use and were translated into several languages. The language settings of the content are not dependent upon browser language detection, but upon the users' preferred language which can be pre-selected. If the preferred language is not supported by the system then the games are presented in English. The multiplayer architecture is hosted on a remote server and includes several components including Linux, Apache HTTP Server, MySQL and PHP (Awwal *et al.* 2015). The database is presented as a relational structure and the application packages are configured to support the various target languages and output the resultant game view at the client's end.

The application 'Node.js' has been used to create a cross-platform runtime environment. It is specifically useful for real-time web applications, as in this study, since it employs 'push technology' over Web Socket allowing both students and the server to communicate freely and at efficient speed. The event-driven architecture employed by Node.js allows for good scalability due to the non-blocking of input-output communication of its application programming interface. It contains a built-in library which allows applications to act as a Web server without requiring additional software.

The games are used in educational settings, and most commonly in schools, where internet connections can be unstable and present problems for working in online environments. To reduce the impact of these factors on game play, if a student encounters a technical problem, closes their window, refreshes or presses the back button on their browser the system will allow both students to re-enter the game at the same state that they left. Both students can move, together, through the pages of the game in a linear fashion. On completion of one game the students are redirected to the game dashboard with the option to select another game.

2.2 Game engine

The multiplayer game structure is presented in Figure 1. The collaborative environment followed some essential steps to give users access to the games. Students log into the system using unique logins, and each pair is connected by a unique team code. On successful login, the student arrives at a virtual room, referred to as the 'Game Lobby' and is presented with a selection of games. Once students select a game they are provided with options to select a role, A or B, which, unknown to them, provides alternate views of the game. After selection of their role they are moved through to the 'Game Room' on the basis of predefined rules such as the correct combination of unique task identifiers. The first student to enter the 'Game Room' is informed that the room is waiting for their pre-assigned partner to join them. The second student of an assigned pair enters the virtual 'Game Room' created by the first student.

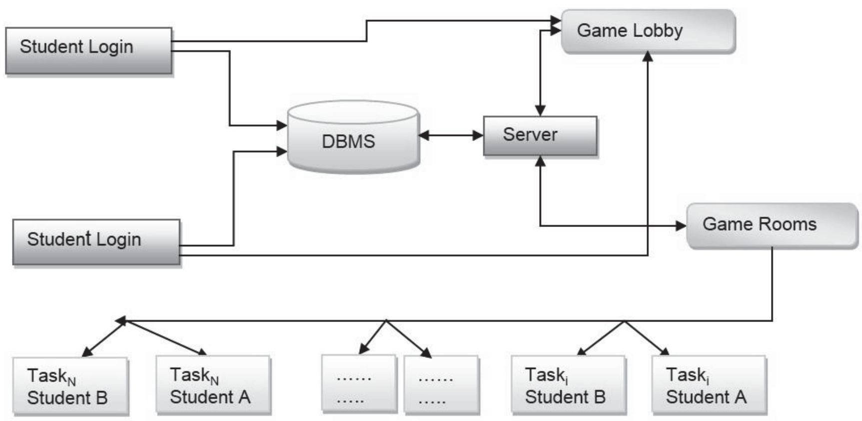

Figure 1: Multiplayer game structure (Adapted from Awwal *et al.* 2015)

2.3 Game design

Each game in the ATC21S™ project presents an embedded 'chat box' to enable both students to communicate via text during game play. While paired under a session, students can collaborate or operate between themselves within the game. During game play every action (selection, movement and clicks) and communication completed by each student is captured in a log file in a time linear structure. It is important that every event is captured in the database as each action and communication, even if ineffective for collaborative problem solving, is used to interpret the students' performance and experience in the game. Each game is presented similarly, with the content and context varying. An instruction stem is presented first, followed by a problem, with each game varying in length from 1 to 8 pages taking 5 to 25 minutes each. Many of the games present asymmetrical perspectives, providing different information and resources to each student, thereby increasing their need for collaboration. Sharing resources and information between each student's screen or through the chat box is critical in building the students' understanding of the problem and ultimately solving it. The games also vary in difficulty level; some require less collaboration but are cognitively more difficult, while others are cognitively easier but require efficient collaboration to solve (Care *et al.* 2015). Students are encouraged to complete a minimum of three games, to allow for sufficient data to be captured for assessment purposes. The games are generally presented in increasing complexity, with the easiest game presented first, and the most difficult last.

HTML5 has been used to develop the games. HTML5 is very suitable for online game development for many reasons, but the most significant reason is the Canvas element, a 2D graphics application programming interface (API). HTML5 allows cross-compatibility with all of the major web browsers, including Firefox, Internet Explorer, Chrome and Safari which provides ultimate flexibility to the user. HTML5 also provides good support for audio and video, reducing the dependability or need for third-party plugins. HTML5 enables the storage of structured data, in place of cookies, using functionalities 'sessionStorage' and localStorage' (Geary 2012). This is especially useful in environments where the internet may be unstable and where data cannot be transferred to the permanent database immediately.

The multiplayer components of the games are supported with the use of the Web Socket application. Web Socket allows for a bi-directional instantaneous communication between servers and clients. It employs a JavaScript interface to enable the communication between students allowing for resource sharing of graphical or textual information, promoting in-game collaborations. The Web Socket allows interaction between the students and the server possible, facilitating real-time communication. This connection enables information and messages to be sent back and forth between the server and the client browser without restricting information flow. This presents opportunities for each student to interact with the objects or resources presented to them. When an action is completed by the student, the game sends a message through the Web Socket to the server, and the server then sends that message to the other client, the other student, or partner to inform them of the action.

A common functionality across the games is the dragging and dropping of objects or resources within and between student screens. For this functionality Phaser has been used, which is a graphics library based on Canvas. It runs faster than Canvas on computers or browsers, using Web Graphics Library (WebGL) and has a wide range of animation options. Phaser offers a variety of canvas scaling options so that the game can be adapted for any screen size or resolution, and can be supported on all major devices and browsers.

In Figure 2, a portion of the 'Oil transfer algorithm' from the game 'Olive oil' is presented to describe how HTML5, Phaser, and WebSocket have provided the functionality behind such game mechanics. In order to achieve the objective of the game which is to fill a jar with four litres of olive oil, the students must work out what resources are available and are needed to solve the problem. Both students are presented with different resources; Student A has a three litre jar, olive oil tank, transfer pipe and bucket; Student B has a five litre jar, transfer pipe and bucket. Without knowing what is available to the other, the pair have to recognise that Student A must fill their jar at the tank and place it under the transfer pipe so that Student B can accept the oil from the pipe. Until this point, Student B cannot complete any meaningful actions and is dependent on the actions and interactions of Student A. Both students need to explore and navigate the game space together until they can place four litres in Student B's jar. Figure 3 presents the game with Student A's screen view on the left, and Student B's screen view on the right.

```
Phaser.page.game = new Phaser.Game(&60,440,Phaser.CANVAS,'canvas');
    // Creates a game domain to play the task with the size
    var main_state = {
    preload: function()
    {
    // Change the background color of the game
     page.game.stage.backgroundColor = '#ffffff';
     // Load the tank sprite
      page.game.load.image('oiltank', 'assets/tank_v2.png');
    },

   create: function()
   {
          // set up the jar in the specific coordinates.
         page.jar_A = this.game.add.sprite(Xcoord, Ycoord, 'jar');
          // Enable input detection, then it's possible be dragged.
         page.jar_A.inputEnabled = true;
         page.jar_A.input.enableDrag();
        //Handle drag and drop
        page.jar_A.events.onDragStart.add(dragStartA, this);
        page.jar_A.events.onDragStop.add(dragEndA, this);
        socket.emit('oilTransfer', {'oilAmountA': page.oilAmountA, 'transferStatus': 1});
    }
   };
```

Figure 2: Oil transfer algorithm in 'Olive Oil' game

Figure 3: Student A's screen view on the left and Student B's screen view on the right

The first line of the algorithm in Figure 2 creates a game domain using Phaser with Canvas embedded within, to draw or move the different objects for the game in that domain. 'Preload:function' is used to define the background setting of the page and also to load up the required image for the game. 'Create:function' is used to allow the objects and images to be dragged and dropped and enables other functions of the games to achieve the desired solution in the game. Different actions are captured by using the function 'onDragStop.add (dragEndA, this)' based on the selection of the objects and the coordinates of the dropping area of the selected objects. For example when a student selects the empty jar and drops it on top of the area of the bucket, then this function enables and calls subsequent sub-functions such as 'Throw-oil-to-bucket'. In a similar way all other actions occur between students through functionalities that are defined to perform those activities. Using 'socket.emit' command in the algorithm, Student A sends request to Student B to transfer oil through server. Once Student B acknowledge to the request of Student A, then the requested amount of oil is transferred to Student B.

3. Conclusion and future

A key criterion of the ATC21S™ project is to develop interactive games that use synchronous communications to provide support for a collaborative process. HTML5 has been gaining momentum over Flash in creating such applications. Unlike Flash, HTML5 is supported by all devices (such as Apple iPads) and is not constrained by licensing limits for the use of additional server based software. It can accommodate synchronous communication among thousands of users and thus allow for scalability on the level required by most projects. HTML5's Canvas element provides an accessible technology that supports game development. To design multiplayer games that demand collaboration over single player functionality is not easy. However, as new technologies such as HTML5 with Canvas and Web Socket have shown such development is possible while ensuring consistent game flow and a positive user experience.

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A Model Driven Architecture MDA Approach to Facilitate the Serious Game Integration in an e-Learning Environment

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Abstract: The development of serious games has increased remarkably in recent years. Serious games provide motivation, dynamism and attractiveness and as a result, they have been integrated more and more into e-learning practices. This integration involves the creation of adapted and entertaining scenarios resulting from the gamification of learning processes and potentially of industrial processes. These game-based scenarios are generally executed thanks to a serious game environment but they should also be integrated more broadly into general learning paths. The creation and integration of serious games represent an expensive process in terms of time and funding. A conventionally simplified approach consisted in using standards. Many standards exist for pedagogical scenarios. Unfortunately there are almost none defined for gamification and/or game-based scenario integration in order to reuse their elements. In this article, we propose a contribution that offers a suitable design and smooth integration of game-based scenarios into learning environments by (re)using existing standards and an engineering model-driven approach. Specifically, we use the methodology proposed by the OMG MDA. Several e-learning standards have been proposed, such as LOM, SCORM and IMS-LD. LOM is a standard used for describing interoperable and reusable learning objects in order to be able to exchange information. These standards are not capable of representing all of the dimensions of serious games as they neglect the fun aspects such as the type of the game, motivation and the integration of games in e-learning environments. However, several studies propose metadata schemes based on the LOM standard to describe serious games (LOMFR-SG, SG-LOM). From these two approaches, we propose a generic enriched description of metadata for serious games in order to characterize a generic meta-model. This meta-model represents an independent level of abstraction. Then, according to MDA, we propose a meta-model suitable for our generic Learning Adventure platform, as well as the Claroline Connect one (LMS). Our contribution permits a smooth integration of serious games in e-learning environments. We propose the use of MDA to facilitate the implementation of generic concepts within an existing Serious game platform and e-learning environment.

Keywords: game-based learning, MDA, serious game

1. Introduction

Currently gamers all around the world invest 3 billion hours a week playing online video games (Wish and Mahleb, 2013). This tremendous "waste" of time could be reoriented to better purposes. Especially since games solicit intense concentration and deep focus from their users, which leads them to grasp their content more efficiently. Recent studies (Treviño-Guzmán and Pomales-García 2014) and statistics have shown the effectiveness of educational serious games in terms of motivating and engaging students in the learning process. So the time reserved for video games could be redirected to help the students learn relatively boring fields of study. Also, an industrial benefit could arise from the use of serious games. This benefit comes from providing the industries' employees and operators with a flexible and realistic virtual environment adapted to their own pace. This process is very profitable for industries as it spares them the expense (equipment, resources) usually expected with training. It also provides them with higher-quality learning, which leads to better long-term productivity. Generally, serious games enhance the level of concentration and interest by providing curiosity, beauty, fantasy, fun, and social recognition, prompting and challenging the learner to dig deeper into the game and gain the maximum knowledge.

Despite the growing trend of using serious games, the financial and time costs are still a major barrier to overcome. Serious game development requires a vast investment in 3D environments which is a very costly business (Slootmaker et al, 2014). Furthermore, the development and evaluation of didactical game scenarios is a time consuming process that requires complex skills. These factors discourage industries and institutes from using this new technology especially when they are unable to reuse its components such as resources or scenarios. Also, these games may not be adapted to different platforms, which represent another obstacle. For example, industries using different platforms to run serious games are unable to exchange them because the game components are not adapted to different platforms. This lack of interoperability prevents industries and educational institutions from shifting from the use of a specific platform to execute serious games to that of another one. Therefore, industries are reluctant or even unable to exploit the features and advantages of new platforms.

Our contribution aims to tackle the problems of reusability and interoperability of serious games in order to amortize their cost and encourage industries and institutes to invest in the serious game sector. This contribution represents a model capable of properly representing a didactical scenario that includes serious game aspects. This model is meant to make pedagogical and serious game scenarios reusable through a variety of platforms. In the following chapter we will shed the light on the work and research that have been proposed in the same area of interest and we will mention their limitations. The third chapter will detail our proposed model and point out its major contribution. The following section will describe the phases of elaborating an operational process interpreting our needs in a serious game context. Finally, we will conclude by discussing our work's advantages and limitations and possible improvements to it.

2. Related work

Early studies in the EIAH field were concerned with describing and standardizing e-learning meta-data schemas. Many research studies (Grant, 2002) (Kelle et al, 2011) have proven that e-learning standards have the potential to extend game design and enrich it with pedagogical elements. However these standards are still unable to represent properly serious game design and cover all of its aspects. This limitation might be exceeded by introducing new standards that are based on the existing ones and enriched by serious game specifications. The following section presents the basic e-learning standards along with the different extensions that were made to meet serious game requirements.

2.1 E-learning standards

Standards and norms are generally established to describe and index the content of an object and to make it reusable and interoperable. In this context, several standards (Hendrix et al, 2013) have been developed to describe real libraries such as AACR (Anglo-American Cataloguing Rules) and LCC (the Library of Congress Classification). The concept of standardization has been exploited in the educational domain to describe e-learning metadata. Those metadatas define the key elements used to describe e-learning courses. They are assembled into a meta-model. A model represents a generated instance from the defined meta-model. These concepts are interpreted by the emergence of e-learning standards such as IEEE Learning Object Metadata LOM (IEEE LTSC, 2002). This norm is mainly designed to describe reusable independent learning objects and enable their sharing and exchange between different establishments. It represents a set of metadata grouped into 9 categories and capable of describing resources in a scenario or learning path.

Another notable e-learning standard is the Sharable Content Object Reference Model SCORM (ADL, 2004). It allows the packaging and aggregation of the learning units while specifying the means of communication between the client and runtime environment. This aggregation is called SCO (Sharable Content Object) and it is primarily used to organize pedagogical resources. Serious games can be packaged, integrated and deployed in e-learning environments such as the SCORM package. However, they would not be properly presented, since SCORM does not contain the appropriate fields and properties

Another commonly used standard is IMS-LD (IMS Global Learning Consortium, 2003). It represents a formal description of pedagogical scenarios. This standard is derived from the IMS consortium whose fundamental task is the standardization of all data exchanges within e-learning environments. This consortium has proposed a number of standards. We can mention among them IMS CP (Content Packaging) which is the currently used resource in Moodle. There is also the IMS Common Cartridge standard that will soon be integrated in Moodle 2.0 (Burgos et al, 2007). IMS-LD is a theatrical language that can characterize a course pathway or a scenario progression using keywords such as (acts, play, roles and actors ...). It revolves around a learning unit that assembles the whole of the scenario specification and contains the objectives, prerequisites, actors, educational activities, the terms of implementation and use, the resources used and results and outputs obtained. The head of this unit consists of a method that can be broken down into a set of plays executed in parallel. Each play is divided into acts which will be executed sequentially. Each act includes a number of activities associated to a particular role; this association is called partition. An activity will be performed in an environment that includes services and resources.

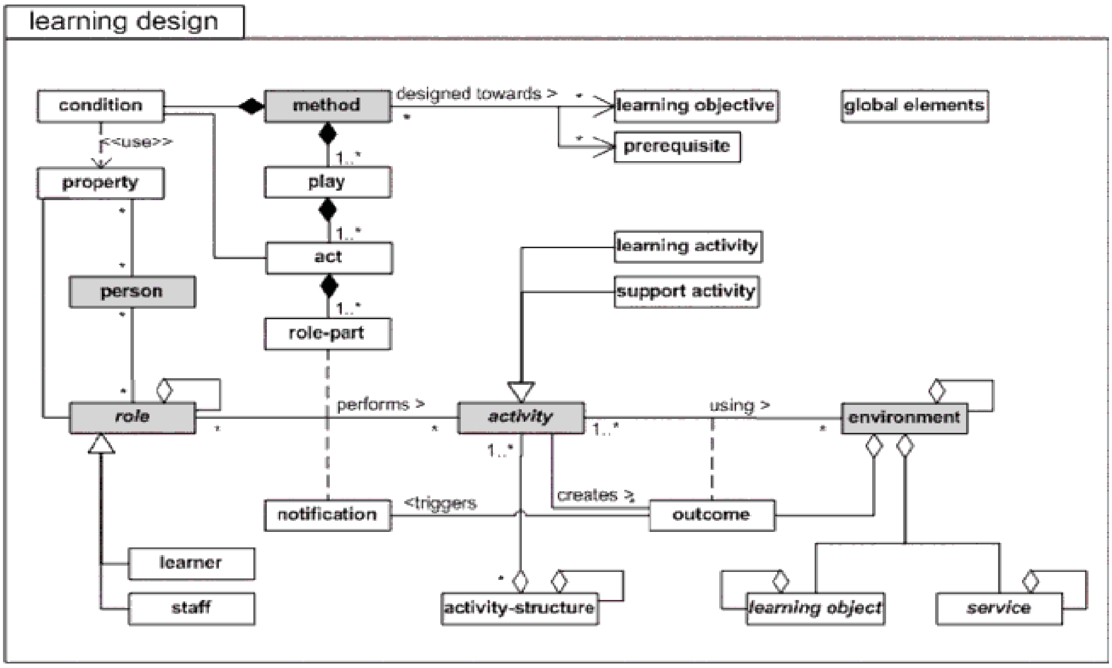

Figure 1: IMS-LD schema (Thanos and Borri, 2007)

Serious games were presented using IMS-LD characteristics, but the proposed description remains incapable of embracing all of the game aspects, as it neglects crucial aspects such as traces and graphical descriptions.

After specifying the basic e-learning standards representing the backbone of any further work, the following subsections will identify the different extensions that have been elaborated based on e-learning standards. These extensions aim to describe properly serious games which will promote their reusability and interoperability.

2.2 Enrichments and customizations of e-learning standards

As the emergence of e-learning norms as internationally recognized standards effectively started with LOM, we are going to start this section by mentioning the studies originating from this standard. One of the most important refinements is called LOMFR-SG (Marfisi-Schottman, I., George, S., and Tarpin-Bernard, F., 2011) . It is based on the norm LOMFR which is an extension of LOM. Aside from the descriptive fields offered by LOM, LOMFR adds other elements such as the description of didactical activities (learning, collaborating and observing). It also includes fields enabling the proper assessment of Learners' skills. Although LOMFR provides very enriching amendments, it remains unable to fully describe serious games. To cover this limitation, it was extended. This extension resulted in LOMFR-SG, which added new attributes to describe the fun aspect of serious games. The added elements of LOMFR-SG are divided into educational, functional and component editors. LOMFR-SG has proved its efficiency in describing particular serious games. However, it remains unable to capture serious games' important characteristics such as rule specification and graphical description.

Among other customization efforts based on the standard LOM, we can mention SG-LOM (El Borji and Khaldi, 2014). It is a collection of metadata describing and defining serious game components. In order to properly index game objects, SG-LOM is built upon four main concepts. The first of these is gameplay and it includes game rules, methods, scenes and time. The second one is storytelling and it embraces the activities' sequencing and organisation within a scenario. Game design is another important factor which focuses on a game's technical aspect. The final game pillar consists of its context which covers the target audience and the description of the game environment. Despite the possible adaptation of SG-LOM to serious games, it still lacks important information relevant to games, such as gameplay and graphical description. Furthermore, it does not improve the game's adaptability to learners' progress, choices and results.

Due to the unsatisfactory results, further studies were based on another norm which is SCORM. One of these studies (Bisognin, Carron, and Marty, 2010) proposes a new standard called SGORM (Serious Game Object Reference Model). It includes game requirements such as emerging technologies. SGORM provides a runtime environment and a communication protocol. The SGORM protocol enables the exchange and integration of external components in the running game. This integration allows learners' skills to be tracked and evaluated.

The value of this work has been appreciated through its application in various experiments. However, these applications have revealed some inadequacies, such as the lack of proper graphical adaptation. Moreover, this work covers just one aspect, which is external objects, while we aim to generalize this approach to include all of the game components and make them reusable and interoperable.

To establish this goal, more promising studies have emerged. One of these studies is MoPPLiq (A Model For Pedagogical Adaptation of Serious Game Scenarios). To provide a proper description of serious games, this new model relied on a special framework as explained in (Marfisi-Schottman, 2013). This framework encompasses 6 facets covering all serious game aspects. These facets are composed of Educational objectives, domain simulation, game simulation, problems faced, decorum (motivational factors) and finally the game conditions and terms of use. The MoPPLiq model (Marne et al 2013) attempted to cover all of these aspects. It was introduced as a model capable of illustrating activities adapted to the learner's choices and reactions. The learners' results after the accomplishment of an activity can trigger the next one. This was achieved by characterizing each activity by an input and output state along with a secondary goal. This model represents a simplified version of IMS-LD, focusing mainly on the adaptive aspect of a scenario and neglecting other important aspects such as graphical aspect and game context. (Hendrix et al, 2013), (Hendrix et al, 2013).

Other attempts were made to cover these limitations. One of these attempts is called IMS-LD-SG (Tran, George, and Marfisi-Schottman, 2010). It consists of a new model based on the standard IMS-LD. It proposes to add a higher level of specification named module. A play is composed of a set of modules. Each module is composed of several acts. This structure allows a better sequencing of acts and activities. However, it fails to cover all of the important aspects of serious games such as representing interactive activities, the graphical aspect and players' traceability. As mentioned previously, a wide variety of studies have been elaborated to offer a model able to properly describe serious games. Such a model should be built on e-learning standards to facilitate its integration into e-learning environments and to make it reusable and interoperable.

2.3 Discussion and limitations

As explained earlier, previous work and studies have generally failed to deliver an appropriate model to reach our goal. We were able to identify the drawbacks of each research by exploring several studies (Tang, Hanneghan, and Carter, 2013) related to game design and characteristics. These analyses enabled us to determine the right criteria that should be considered when evaluating serious games. We concluded that an adequate game design should meet the following requirements: elaborate a proper graphical description, specify the game context, promote the adaptive and interactive aspects, determine the game rules and conditions, and track the learners' progress during the game.

The following table will illustrate these points. It will determine the compliance of each standard with the specified requirements by mentioning the fields that have allowed this conformity. It will also reveal their deficiencies.

Table 1: Characteristics of the different aforementioned propositions

	Graphical description	Interactivity	Adaptability	Context	Traceability	Game play
LOMFR-SG		- Interactive resources - Didactical activities		- Target public - Motivation	- Score -Completion rates	
SG-LOM		- Multiplayer value		- Game type		

	Graphical description	Interactivity	Adaptability	Context	Traceability	Game play
SGORM	-Graphical representation	-Collaborative elements	- External files		- Widgets for traces	-Scene specifications
MoPPLiq			- Input state - Output state - Secondary objectives		- Learners' choices	- Properties and conditions (game rules, time)
IMS-LD-SG			-Notification			- Properties and conditions

After evaluating the prior attempts to provide interoperable and reusable serious games, we will present our solution. This solution aims to improve the previously mentioned weaknesses. The advantage of our work is that it covers all of serious game aspects mentioned in the previous table (see Table 1).

3. Towards a new design model adapted to serious game concepts

The challenge faced in our study is to be able to use the previous work by choosing the adequate e-learning standard as a starting point for our research. The following step consists in carefully specifying the right elements to add, eliminate and alter in order to shape the right model. This model will be exploited later in order to form an operational process for serious games to be able to be reused and integrated into different platforms. In our research, we seek to define a metadata schema capable of appropriately scripting a serious game scenario or a pedagogical course. In order to elaborate this schema, we chose to base our study on the particularities of the IMS-LD standard, as it reflects the focus on the scenario. In this model, we address certain aspects mostly related to serious games in order to properly describe the different game specifications. Several amendments concerning IMS-LD elements should be established to fulfill this goal. We will present this model's construction by explaining its different phases

The first measure taken is to adjust IMS-LD elements to represent simultaneously both educational and game objects. This simultaneity is established by defining the pedagogical aspect and the ludic aspect of the key elements separately. As shown in figure 2, the class Activity is defined as pedagogical activity and ludic activity. We applied the same concept to the classes Environment, Role, Context and Indicator.

A game scenario is composed of a variety of game objects such as characters and resources. These elements can be simply described for educational purposes or expressed as graphical 3D objects referring to actions, directions and motions. Graphics represent a very important factor in the game as they allow the definition of the game components such as characters, resources, simulations and scenes. For this reason, the graphical aspect of the game should be wrapped inside the model. It can be expressed by providing the characters, activities, context, indicators, objects and environment with a class named attribute. The value of this class can be adapted to describe the required graphical specifications.

Furthermore, in pedagogical courses, resources represent only physical or digital tools such as tests, URLs, figures or videos. These are valid possibilities for serious games, but there are also other kinds of resources which are other secondary characters in the game. This possibility is included in our model by establishing an inheritance link between the ludic role class and scene objects.

The next phase of amendments focuses on exploiting the dynamic aspect of IMS-LD to adapt the educational scenario to the learner's performance. In order to set up this adaptability, we decided to use the MoPPLiq aspect and exploit its particularities. So, we adapted our work to include MoPPLiq design by associating to each activity, an input and output states along with a particular objective. These changes are shown in figure 2 by incorporating the classes' state, input, output and objective. Also we specified the type of relationship linking input and output states. This type solved the problem of the regular course of activities being interrupted by a general activity or other factors. This interruption will be designed thanks to the type of relationship or link.

In addition, we can assign some conditions to reach a certain state, especially output states. Figure 2 presented this concept by linking the class condition to the class state. The final phase of changes consists in adding new elements that were irrelevant to previous research. These elements cover both educational needs and game requirements. However, they can be represented differently depending on the situation. The first element is the context of a game or educational course. It is an important factor to consider in a learning path design as certain studies (Benson and Samarawickrema, 2009) (Benson and Samarawickrema, 2007) consider it as a complex, multifaceted, perspective-dependent concept. A context may be composed of different elements defining learning, institutional and disciplinary characteristics. Its main role is to offer a realistic contextualised environment. Such an environment enables the learner to better understand the situations. Moreover, it permits the accurate assessment of the learner's skills and progress in real world situations. As far as it concerns serious games, the context can be broadened to include both the game simulation, containing game particularities such as Front-end displays, dimensions, tempo, scores and rules, and the game presentation. As proof of its strong influence in serious games, this element was included in Four-Dimensional Framework (4DF)(Van Staalduinen and de Freitas, 2011), which was considered an efficient framework to design games.

The second element added to our model consists of Competencies and Performance indicators assembled to track the learner's activities.

The following model provides a conceptual approach to assemble traceable events indicating the learner's strategy. It will allow us to assess the learner's skills not only through his/her results but also through his/her behaviour. These indicators and results should be stored in a record representing the history of different activities and interactions that took place during the game. This record is presented in figure 2 by the class record. This class is linked to the classes result and indicator to assemble any information coming from them.

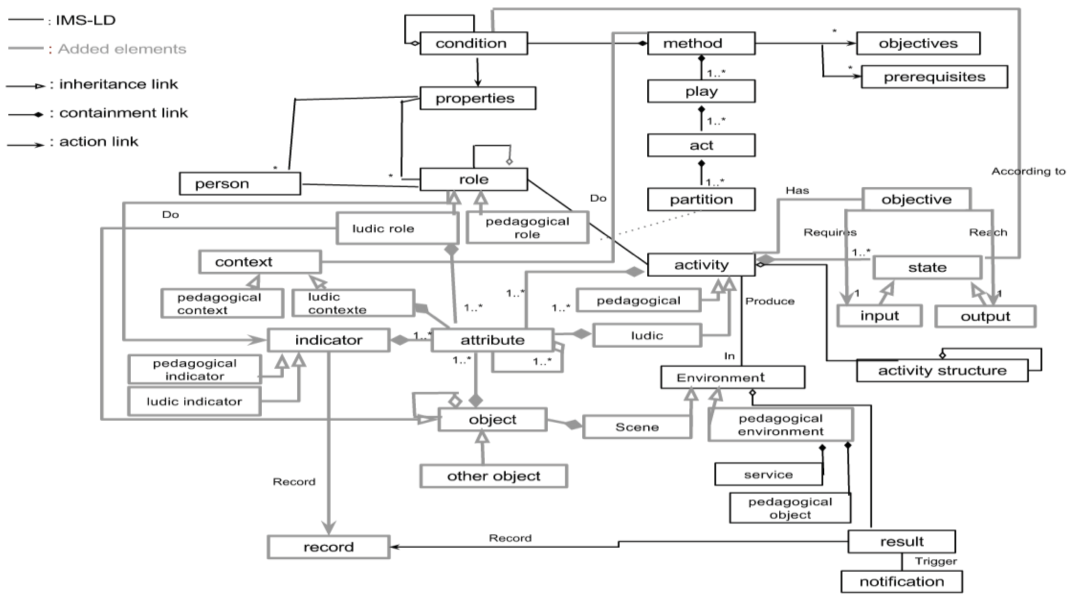

Figure 2: Our proposed design model

The next step of our work is to transform our theoretical model into an operational efficient process. To successfully establish this transformation, we have to make an important choice. It consists of determining the more appropriate approach to structure our plan of action and determine the different steps of our process.

4. MDA approach

The chosen approach to realize our ideas is named MDE (model-driven engineering). But before exploring this approach, we will present it and explain its mechanisms. MDE aims to raise the level of abstraction and automate the development process by using executable model transformations.

The implementation of this specific approach is called Model Driven Architecture MDA (Brown, 2008). The basic level of MDA is metamodels. The next level of abstraction is called Platform Independent Model (PIM). It is a generative model compliant with the earlier defined metamodel. The final transformation generates a Platform Specific Model (PSM) which describes a realistic application. This description is adapted to the specification of the target platform or environment. The implementation of this approach requires the use of certain frameworks. One of these is Eclipse Modeling Framework EMF. It facilitates the design of a structured metamodel which represents the bases of MDA implementations. There is also the Graphical Modeling Framework GMF provides a runtime infrastructure to develop graphical editors. This editor provides a graphical model compliant with a previously specified metamodel. Another framework is ATL Atlas Tranformation Language. It is a model transformation language. It permits to generate the PSM model through setting up a model to text transformation. The figure below illustrates the MDA approach and the frameworks employed

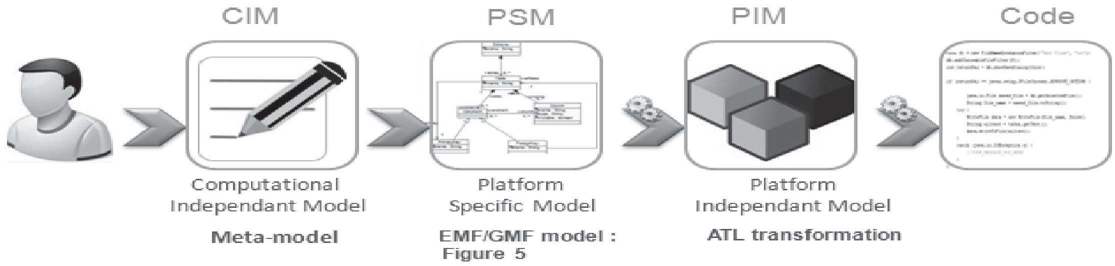

Figure 3: MDA approach and included framework

We adapted this approach due to its promising potentials that suit our needs. These potentials include portability, meaning that its functionalities can be easily migrated into new platforms. Also, MDA offers improved productivity and time-to-market because by automating the development tasks, the developers and architects can fully concentrate on the logic of the process. MDA facilitates the integration of the system into other ones. With regard to the notions of testing and simulation, MDA is a very efficient method as models can be directly tested against requirements and specified constraints, as well as against various infrastructures. They can also simulate the behavior of the system theoretically using only the design, which enables the system to be double-checked before realizing any unpredicted risky implementation. In the following section, we will detail the implementation phases of our specific use case.

5. Use case implementation

One of the important steps in our work is to implement our model and be able to formally represent serious games and e-learning courses based on its elements and specifications. For this reason, an authoring tool has been created. The goal of this tool is to enable us to realize model-conformant concrete examples describing a serious game scenario or a learning path.

This authoring tool has been developed to assist the participants involved, such as teachers or game designers, in designing an adequate model. It allows them to easily express their specifications, without requiring a lot of experience in the computing field.

The formal expressions of our basic metamodel are expressed thanks to EMF, as shown in figure 4. These expressions correspond to the level CIM of the approach MDA. They will be transformed to another level of abstraction. This transformation will enable the creation of concrete models compliant with the metamodel developed using EMF. The generated models represent the PIM level of MDA approach. This metamodel will be transformed using GMF to allow a graphical representation of its concepts. This representation will help game designers and pedagogical instructors to set out their requirements using only the existing concepts. It will also be used to design the scenario as elaborated in the following figure. This design represents the level PIM. Figure 4 represent the interpretation of our design in real world and its integration as a course in a claroline connect platform

The developed serious game examples compliant with our model will be translated afterwards to a markup language such as XML or json. This translation is established thanks to ATL and it represents the PSM level. This transformation will translate the serious game example presented in the form of classes, relationships and conditions into a recognized format. This will provide us with a package encapsulating all of the essential elements that need to be integrated into e-learning environments. The generated file will encompass the reusable element and it will be incorporated into a serious game platform. The required steps for this integration are well organised by SGORM protocol. They start from creating the LG (Learning game) components that correspond to the encapsulated elements. The next phase is to establish a communication between LGMS (Learning Game Management System) and LGC provider (Learning Game Components provider) to build up the specified components as external objects. Finally, a notification system will be established. It will notify other servers of a new LG components' authoring.

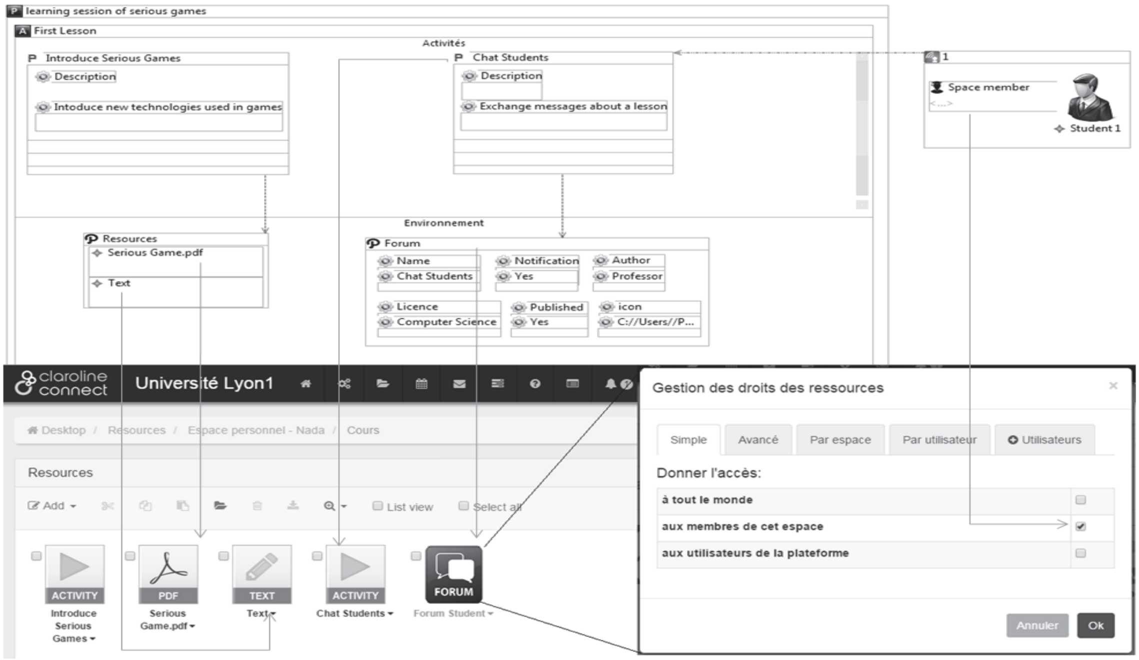

Figure 4: A Claroline connect course scenario elaborated in our graphical editor

The next figure (Figure 5) will illustrate the interpretation of our design as a serious game. It will explain how each element in the design represents a concrete element of a serious game.

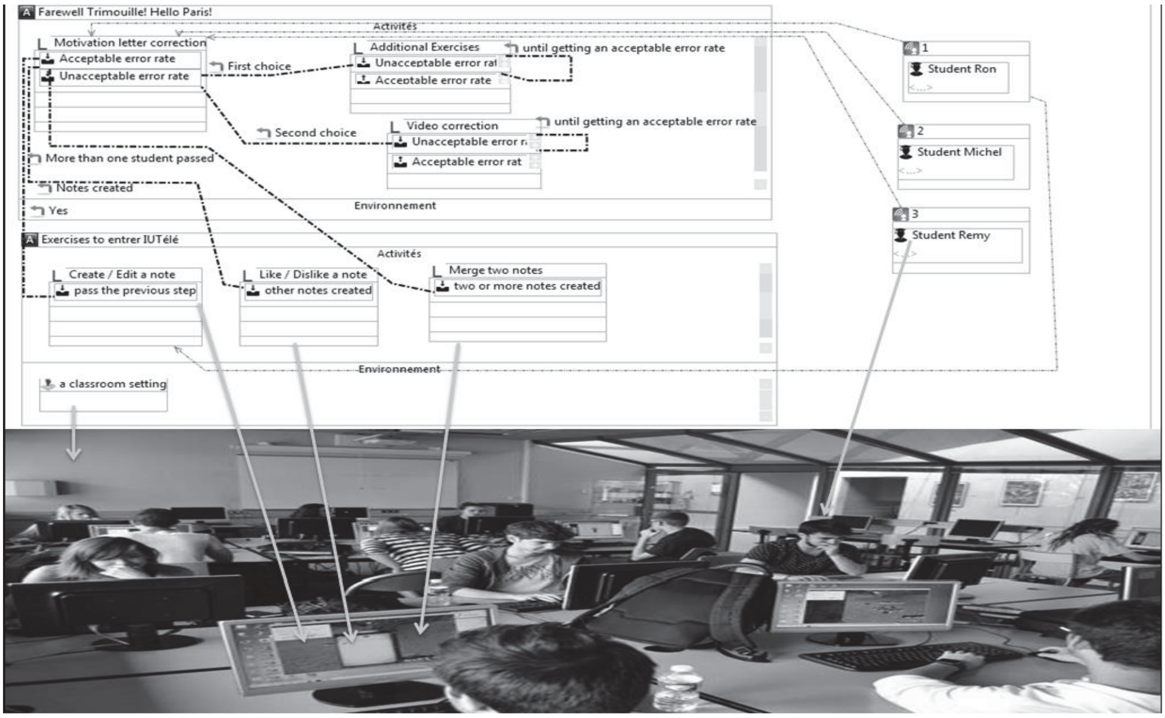

Figure 5: A serious game scenario represented in our generated editor

MDA architecture guided us through all of the development phases. We were also able to make use of all of its particularities that exactly match our process requirements. Using this approach, we were able to fulfill our goal and deploy our scenario in different platforms, making it a reusable and interoperable component. Moreover, the ability to separate different concepts was very helpful in producing a consistent process, as each step was well thought out.

6. Conclusion and future work

This paper has presented us with an evolution of the IMS-LD standard realized to embrace serious games' designs and highlight their various aspects. The model proposed harvests the different elements related to serious games' scenarios, presenting both the pedagogical and ludic aspects. These scenarios will be properly designed using prescribed concepts, implemented thanks to an authoring tool specially developed to shape serious games' scenarios and encapsulated into a reusable package. We will adjust this package to be easily integrated into a variety of platforms.

Despite the ability of this model to express most serious game elements and the potential of this process to produce fruitful results that elaborate reusable and interoperable serious game scenarios, there are certain inadequacies that need to be pointed out. Concerning the drawbacks, our proposed authoring tool is not ergonomic enough to easily guide the game designer or teachers through the process. It will take them a certain time of reflection to properly master this tool. There is also the problem of the emergence of new platforms containing new features and advantages. In this case, the generated package should be updated and adjusted to the new environment's specifications.

The previously mentioned issues should be covered in the work to be carried out in the near future. An important perspective of this tool is to build, based on its specifications, an adequate player able to execute and run the serious game models and scenarios established in our tool. Consequently, further work may elaborate a complete cycle for our work from design to execution, which will lead to a new environment specific to serious games. This environment may include new characteristics and specific attributes concerning the core of serious games.

As explained in introduction, we consider that a serious game will/must evolve and may be reused in other context. The return of investment is important both for companies that elaborate the serious games and those that use the serious games for employee training program.

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Game Design for Learning to Solve Problems in a Collaborative Environment

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Abstract: Gamification has become a central focus in education and training due to its perceived potential to make learning more motivating and engaging. The reason for this shift in focus is that, unlike traditional pen and paper assessments, those presented in the form of games are not only designed and encoded with enjoyable game playing mechanisms, but is also capable of capturing salient information about the problem solving processes that individuals use when they work through a problem with another individual. The Assessment and Teaching of 21st Century Skills (ATC21S™) project focused its research on assessing the processes with which a problem is solved in a collaborative environment. This paper draws on the ATC21S™ study, outliningits approach to assessmentdesign and providing justifications for choices made to achieve participant engagement and maintain a learning flow through a game mechanic that preserves learning outcomes. The game design included false leads to encourage students to explore the space and learn through trial and error. These were part of an instructional technique that allowsstudents to learn problem solving skills in steps or through patterns when one or more of the steps are incorrect. This paper provides a consolidated view of the design process of the assessments used in ATC21S™and shows that learning can occur through exploratory as well as collaborative participation in problem solving within the game environment.

Keywords: learning, collaboration, problem solving, gamification, game design

1. Introduction

In today's knowledge-based world, life-long learning skills such as problem solving, creativity, critical thinking, communication and ability to collaborate in teams are becoming increasingly essential. The advances in technology and changes in the organizational infrastructure have put an increased emphasis on teamwork within the workforce. Workers need to be able to think creatively, solve problems and make decisions as a team. Therefore, the development and enhancement of criticalthinking skills through a collaborative learning environment is one of the primary goals of technology education. Learning approaches that provide environments consisting of meaningful tasks need to be adopted in order to encourage acquisition of the skills by learners through their experiences and interactions. Computer and web technologies can potentially support the creation of such games and environments. The idea of game-based learning is to combine methods of gaming and learning in order to take advantage of the motivation that is intrinsic to game-playing. Digital game-based learning, a newly emerging medium, actively engages students in learning and elevates their higher order thinking (Prensky 2001, Kiili 2005). Games can be viewed as systems that combine simulation, pedagogy and entertainment to create engaging learning. These environments are tailored to provide learning activities and the opportunity to collaborate, problem solve and apply critical thinking skills. With the addition of networks, they become multi-user environments, allowing multiple perspectives, argumentation and collaborative decision making. Measurement in collaborative games consists of observing, capturing, and summarizing complex individual and team behaviours, from which researchers can make reasonable inferences about learning processes and products. The steps each learner takes or retakes as they progress through the problem space (discussions and interactions, learner-to-learner and learner-to-computer) provide opportunities for them to monitor, evaluate, and adapt their learning during collaborative activities (Quintana *et al.* 2004). Moreover, research indicates that collaborative games provide social interaction that generates valuable ideas and discussion that improves learning attitudes and increases self-efficacy owing to the opportunities they provide for organizing knowledge and sharing facilities embedded in the collaborative gaming environment (Dillenbourg 1999, Prensky 2001, Kiili 2005). This paper illustrates the design process of collaborative problem solving games used in the ATC21S™ research and demonstratesthat the opportunity to learn can be embedded within the game design.

2. Games in education

In the present century, use of computer games for various purposes has become widespread in the field of both education and training. Educators believe that children learn best during play and games can give them that opportunity (Vygotsky 1978). Together with good game characteristics (such as goals, rules, interactivity, feedback, challenges) and effective learning principles, well-designed digital games are able to motivate and promote effective learning by providing opportunities for individuals to actively and critically experience, practice, and reflect on their ideas in a problem-based context (Squire *et al.* 2003). Digital games have been found to be helpful in improving spatial cognition, visual attentional processing, perceptual motor skills, and problem solving skills (Johnson and Mayer 2010). To prepare individuals with abilities (critical thinking, problem solving etc.) needed for the 21st century, learning through games as an approach has been advocated for adoption in educational settings (O'Neil *et al.* 2003, Squire *et al.* 2003, Griffin *et al.* 2012). Many researchers have argued that computer games can support teaching, and foster learning and cognitive development. Educational games can present relevant, exploratory, emotive and engaging environments that include complex challenges or puzzles to mediate learning outcomes (Prensky 2001, Masuch and Rueger 2005, Hämäläinen *et al.* 2006).

The design of popular games has been a focus of study for a number of educational researchers, who have investigated how various aspects of game design might be appropriated, borrowed and repurposed for the design of educational materials and learning (Chiu *et al.* 2001, Prensky 2001, Squire *et al.* 2003). The ATC21S™project proposed ways of assessing 21st century skills and encouraged education systems to incorporate these skills into teaching and learning to prepare students to be successful in the workforce and as global citizens. It was realised that traditional assessments may not be suited to the measurement of many of these skills. Hence, the goal was to develop new assessment approaches for those skills and to advise systems, schools and teachers on the use of assessment data to help students develop higher order proficiencies. In this study, the games consists of problems that are complex, ill-structured, and open-ended to foster flexible thinking, support intrinsic motivation, and promote conjecture and argumentation.

3. Theoretical/development framework

The ATC21S™ project focused on the 21st century skill of collaborative problem solving (CPS) and explored the development of digital forms of assessment to match the conceptualisation of this skill with available technology (Griffin *et al.* 2012). CPS has been conceptualised as a complex skill that combines social and cognitive competencies. It links critical thinking, problem solving, decision making and collaboration across five social or cognitive skills; participation, perspective taking, social regulation, task regulation, and knowledge building (Hesse *et al.* 2015). Within each of these skills are subskills which are evidenced by observable indicators of actions or processes. The assessment tasks or games rely on and capture these actions or processes in order for the measurement to reflect the construct.

The skills defined by CPS are pertinent to solving problems that are by definition complex, ill-structured and ambiguous. Collaborative problem solving means working together and exchanging ideas to pursue a common goal. Collaboration in this context requires active participation through searches for relevant information, joint use of resources, shared evaluations and agreement on strategies and solution paths (Care and Griffin 2014).

Three of thefive skills involved in this conception of CPS are social: participation, perspective taking, and social regulation. Participation is determined by an individual's level of interaction and engagement with problems and collaborators. Perspective taking highlights an individual's abilityto understand and show awareness of others' opinions. Social regulation consists inthe strategies for negotiation and initiative used by individuals in their management of the problem space. One clear indicator of collaboration is communication that goes beyond mere information exchange, emphasising an individual's ability to account for others' perspectives and to provide responsive contributions (Care and Griffin 2014, Hesse *et al.* 2015). This indicates the presence of the social skills. The two cognitive skills are the same as those exercised in individual problem solving: task regulation and knowledge building. Task regulation indicates a student's ability to analyse a problem, set goals, manage resources and organise a problem space to explore and aggregate information in an ambiguous environment. Knowledge building is underpinned by skills to plan, execute, reflect and monitor through identification and formulation of connections as a consequence of collaboration (Care *et al.* 2015). The two hypothesised components of CPS are not mutually exclusive.

In the Hesse *et al.*(2015)CPS framework as illustrated in Figure 1, the social component draws on literature from social and organisational psychology while the cognitive component draws heavily on classical approaches to individual problem solving. Research highlights that CPS in computer-based assessment environments includes the conceptualisation of collaborative learning, problem solving, and higher order capacities (O'Neil *et al.* 2003). The ATC21S™ projectdesigned a series of web-based interactive tasks (games are referred to as tasks in this case) in order to measure the subskills and processes characterised by collaborative problem solving. The task design engaged dyads in collaborative problem solving activities while capturing the processes enacted by the individuals to solve the tasks.

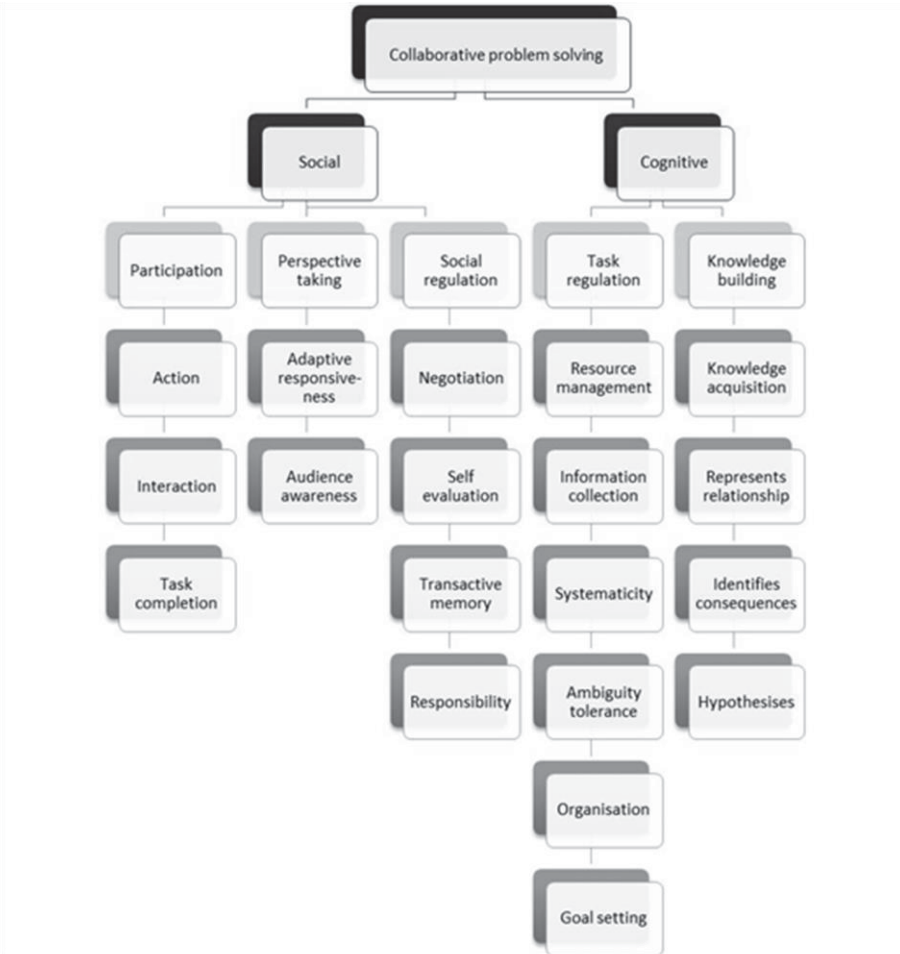

Figure 1: Framework for collaborative problem solving (adapted from Hesse et al. 2015)

4. Game design procedure

The research and development process of ATC21STM followed a conventional approach to assessment design by conceptualising constructs, establishing blueprints, and creating tasks. It took into account the guidelines of game design and the principles of assessment, while introducingsome novel features in assessment design. Tasks developed under this approach involved deliberate use of ambiguity, lack of explicit information, the presentation of complex problems in stages, andthe provision of interaction protocols among the task participants (Griffin et al. 2012). In the construction of the tasks, extensive use of a series of inductive and deductive reasoning tasks was made (Griffin et al. 2013). Several human to human collaborative problem solving tasks were designed and constructed. The purpose of the development was to identify ways to assess the skills described in the framework while at the same time enhancing individuals' understanding of a collaborative approach to support learning. Each task was developed independently of the others without any prior defined template.

Given the theoretical framework of Hesse et al.(2015) and game design process described by Fullerton (2004), the ATC21STM study highlighted the task design procedure in providing a task concept or scenario to sample the skill set described, identifying the specific subskills inherent in the task through gameplay (specific ways in which participants engage and interact with a game), and suggesting the contextual elements and game mechanics (rules or methods conceived for interaction with the game state) relevant to completion of the task for the target respondents or recipients (Care 2012). In this way, atask can be seen as a system in which individuals interact with a virtual environment governed by the game rules and game mechanics from which, eventually, gameplay emerges. Elements such as participants, their roles, objectives, procedures, rules, underlying game mechanics, resources, underlying conflicts, obstacles and an outcome guides it to function as a game in an educational setting (Masuch and Rueger 2005, Fullerton 2008).

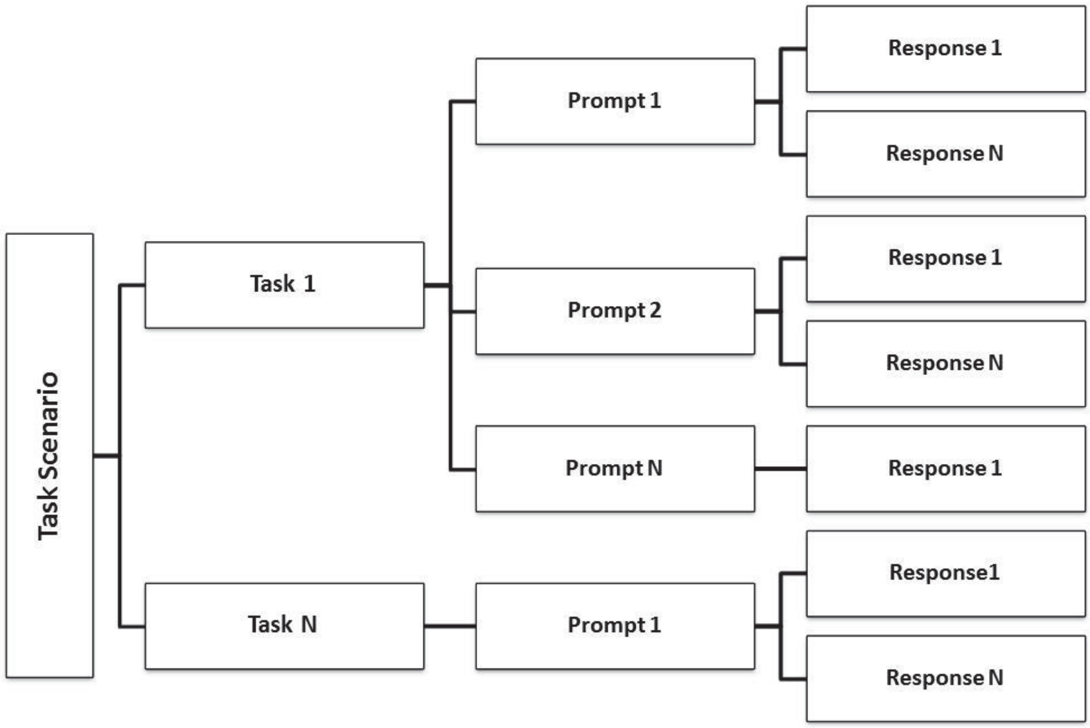

Figure 2: Conceptual task draft

Task concept refers to what the task will look like to an individual and what cognitive processes individuals might need to use to perform the task successfully. In summary, it is a sketching out of what will materialisefrom a performance activity. The task scenario then needs to be described in detail and a series of prompts provided to enable gameplay as explained in Figure 2. The drafting of the task concept in this instance wasundertakenin collaboration with teachers, who wereasked to identify the relevance and appropriateness of the task to students at different age and ability levels. The target population for these tasks ranged between 11 and 15 years.

Most problems in the real world do not simply have a correct or incorrect solution. TheATC21S™ tasks have been designed to mirror this feature of the real world, allowing the problems to have multiple possible outcomes or multiple possible routes in reaching outcomes. This extends the possibility of developing assessments or tasks that encourage individuals to explore ideas previously considered incorrect or partially correct and thus facilitate higher order thinking (Griffin 2014). A naïve way of thinking about CPS task design is to imagine that all participants will be active in the problem space and contribute to solving the puzzle. In some problem spaces, however, it is possible for and individualto do all the work.To avoid this issue, it has been necessary to design tasks thatrequire collaboration (Zagal *et al.* 2006, Zea *et al.* 2009). Tasks have been developed that parallel real life scenarios,presenting problems that are ambiguous, require multiple resources (skills, knowledge, artefacts) and the engagement of individuals who are dependent on one another for successful resolution of the problem(Griffin and Care 2012, Griffin*at al.* 2012). Tasks were designed with either symmetrical or asymmetrical views, i.e.,participants saw either identical or different screens, but in both cases they accessed or controlled different information and resources, reflecting the nature of the real world problems for which the construct is deemed relevant (Care and Griffin 2014).

The development of the ATC21S™ tasks focused on skills that are measurable, learnable and teachable, but that are not personal attributes. An important aspect of task design is the question of whether skills of CPS can be learned or taught, informed by the degree to which empirical evidence of increasing sophistication of the skills occurs (Greiff *et al.* 2013, Care and Griffin 2014). The study necessitated initiation of innovative and rich forms of assessment where task design itself would direct the nature and style of items and therefore measure the underlying dimensions. The aim was to develop prototype tasks (a mix of CPS task types) that can fill a variety of purposes and functions. The prototypes are multimedia exemplars compiled in technology environments that incorporate adaptability and unpredictability and increase assessment efficiency (Griffin *et al.* 2012). Crucially, they also make students' thinking visible and add value to assessment by facilitating learning.The blueprints for the tasks provide guidance to test developers regarding the types of behaviours hypothesised to indicate the subskills and demonstrate the different levels of performance quality.Advice is also provided on constructing a layout comprising task scenarios, the context of each task that can lead to the creation of artefacts to act as resources, and also on prompts in the problem space posed by the task itself.

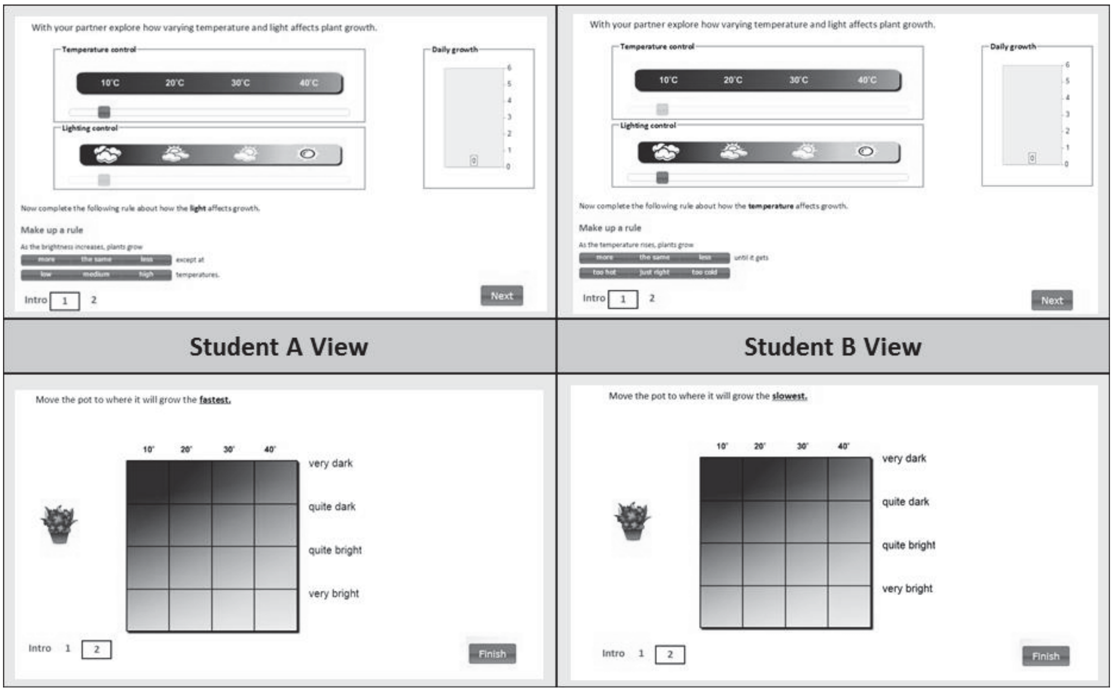

Figure 3: Screenshots from the Plant Growth task

The design method is best understood by reference to exemplar tasks from the ATC21S^{TM} project. In Figure 3, the **Plant Growth** task illustrates how learning is encapsulated within the task design. This task is presented in two levels. It presents each of two problem solvers with control of one variable – temperature or light density – to manipulate the daily growth of plants. The participants are allowed to view the choices made by their partners (without access to their controls) and the effect of their selections on the plant growth. They are required to observe if there is a consistent pattern of growth based on variations in light (very dark, quite dark, quite bright, very bright) and temperature (10^o, 20^o, 30^o, 40^o) when applied together or in isolation. Participants are then asked a question regarding the mechanism of their partner's control, for which, at this level, exchange of information is crucial. On the next level, the role of the individuals is to work independently to assess under which conditions the plant grows fastest or slowest, and then use their understanding to position the planton the grid provided.As exhibited in Figure 4, the task is divided into processes in which, following initial exploration, problem solvers are required to go through stages to collect information, identify patterns, form rules, test rules, generalise rules and test hypotheses. As this task was originally designed to assess cognitive skills, the collaborative skills have been added tothe different game stages (Care *et al.* 2015).

In this example, both parties are required to find patterns, exchange information and generate rules about bivariate relationships. The design of this task can facilitate individuals in learning to solve the problem without any prior knowledge of the subject matter. The layout of the initial level allows participantsto find the best conditions for plant growth by varying the temperature and the light density that each of them controls. This involves both participants exploring patterns, sharing information, generating rules, and investigating cause and effect. The task then tests the participants' understanding of the rules governing their partner's control. This level operates as an exploration space for participants to learn and understand the problem space and the game mechanics. The final level of the game tests the participants' individual learning outcomes; that is, whether they have understood the rules and are able to apply their learning in a different context. This requires both transferring the evidences gathered into relationships and demonstrating separately (where each is responsible for different variables under varied conditions) what the final outcome of the game will be.

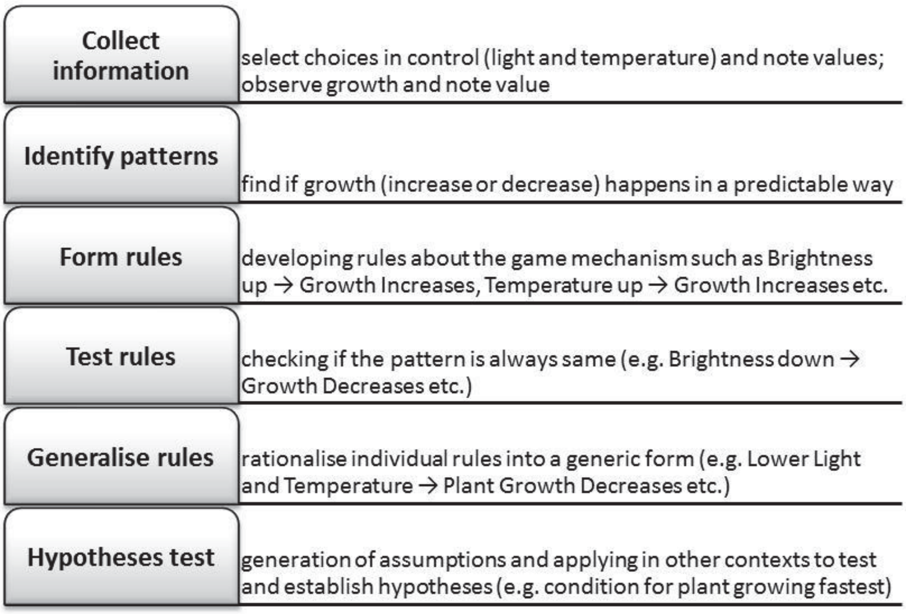

Figure 4: Plant Growth task conceptual design outline

Another example, the **Light Box** task, as shown in Figure 5, demonstrates how learning can be depicted across multiple tasks. This is another example of a multi-level (two-level) task.The aim is to fire the laser and hit the target. In the initial level of this asymmetric prototype, each person from the dyad is to place one mirror in the grid to help align the laser with the target. There are multiple arrangements of mirrors which will result in correct alignments. Unlike the previous task, in this task individuals are unable to see changes made by their partner. The alignment of the mirrors is revealed by the firing of the laser to check if it hits the target. In the identification of one or more correct positions on the grid, collaboration is essential. The final level of the task mimics the preceding level but with changed positions of both the laser and the target.It requires the participants to work independently on the same problem without awareness of each other's work, although it does reveal whether theirsolutions match.

As with all tasks constructed for this study, individuals in the pair across do not have access to each other's screen. In this example the task features have been separated among participants so that tasks are not solvable without a partner, to ensure the collaborative elements are incorporated in the design. The first level offers individuals an opportunity to work together with aim of hitting the target and in the process explore patterns, share information and generate rules about objects and alignments. It provides an investigation space to trial options anddiscuss rules to determine the rules of mirror alignment and positions in order to hit the target. The final level requires individual's to reflect their understanding of the rules and able to demonstrate their learning by applying their hypotheses independently. The ability of individuals to successfully demonstrate the possible correct solution paths for the task indicates evidence of learning.

Using the design principles of gaming, puzzles designed for individuals were adapted to involve more participants. In order for this to occur some of the following were incorporated, namely the need for collaboration, solutions that require equal contribution by both participants, coordination of participants' actions to promote communication and collaboration by organising user separation (every participant cannot see and access the same things). Due to the design controls imposed in the CPS tasks, the collaborators cannot see each other's screen and are limited to sharing of information or resources through a few game elements such as communication interface (chat messaging box) and some shared resources or space; hence, collaboration is deemed critical to progress in the task. The communication interface provides a meansof communication between participants, offering the opportunity to transfer knowledge and discuss strategies while deepening their engagement. Communication is necessary to agree on the definition of the problem at hand and for identification and agreement on a common goal.

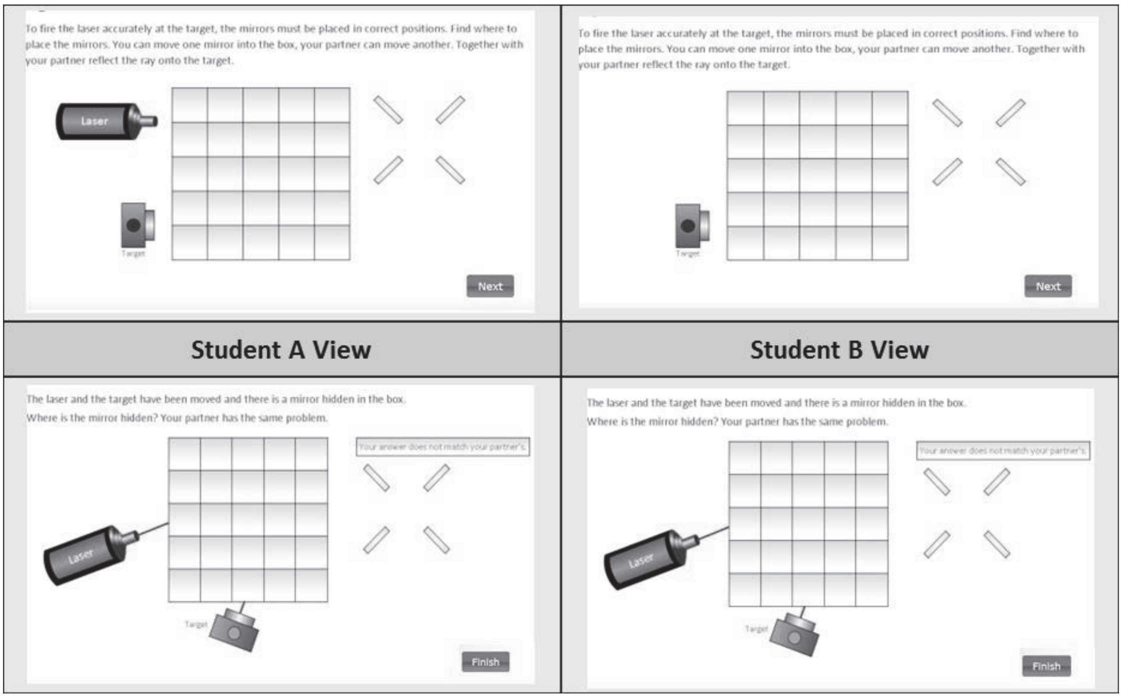

Figure 5: Screenshots from the Plant Growth task

As each individual brings their own prior expertise, knowledge and personal understanding of the game mechanics, the tasks provide opportunity for them to offer unique contributions and to learn from one another, overcomingany misconceptions they may have. In addition, the design and the game mechanics permit some learning to transpire by informing the outcome of the trial and error processes so the individual is able to gain understanding of own and partner's perceptions and learn from their mistakes. This adaptation steers the knowledge acquisition among the collaborators through a process from collecting evidence to performing experiments (doing systematic and controlled observations) that permit testing of hypotheses with the learning outcome of finding a solution to the problem (Griffin 2014).

Research indicates that game playing processes lead to improved performance in which technology acts as a cognitive tool steering meaningful learning. Educational online games such as the ones developed for ATC21S™ offer participants ample opportunity for active engagement and experimentation, control and visualization of concepts, and interactivity with digital educational content and with other humans – a variety of capabilities that address individual and social dimensions of learning (Dillenbourg 1999, Hämäläinen *et al.* 2006). All of these indicate that Vygotsky's Zone of Proximal Development (ZPD) is the cognitive and social space resulting in learning where potential development is determined through problem solving in collaboration with peers (Vygotsky 1978).

5. Challenges and issues

Games have the potential to enhance learning by connecting game worlds and the real world to facilitate collaborative problem solving. The importance of collaborative problem-solving ability has been addressed and included as one of the future components of assessment in PISA (OECD 2003). Despite its benefits, the goals of the games do not always align with the learning goals and the game's features may distract individuals, affecting them cognitively and physiologically. Some researchers believe that the creation of educational games which incorporate learning outcomes into the game mechanic is yet to be achieved (Squire *et al.* 2003). For games to be effective educational tools they need to optimise learning outcomes by offering ample opportunities to construct and apply knowledge as well as to acquire and rehearse skills through active exploration within the virtual environment and collaborative activity through appropriate multiplayer capabilities. It is crucial that games used for educational purposes maintain gaming in the forestage, while meeting educational goals to enhance and expedite learning. Often, poor design of the games involves tasks which are not useful for increasing the students' progress, and so they are centred on simple "drill and practice" models (Squire *et al.* 2003). As a result, games can fail to integrate learning outcomes into their design and mechanics.To become successful educational gamesthey must ensure that children learn what is intended (e.g., science, maths) and not just game-play techniques. With appropriate design of game tasks and mechanisms, collaboration among participants can be promoted to enhance their engagement levels, their game exploration skills and their ability to reflect on their experience to demonstrate improvement in their cognitive performance and problem solving skills (Moreno-Ger *et al.* 2008). However, it is a difficult challenge for game design to successfully balance the contribution and engagement from participants that is required in such collaborative environments (Manninen 2002).

An educational online game is not an effective learning medium on its own. The development of such games should be guided by learning objectives, subject matter and assessment requirements. The design should be such that the gameplay can combine the requirements of traditional single player games (fun, narration, and immersion) with the challenges of multiplayer games (concurrent gaming, interaction). Design and implementation of games is expensive, time-consuming, resource-demanding and challenging. Therefore, to make the design of a collaborative game better facilitate learning, it is important to evaluate games empirically and identify improvements, as was done in theATC21S™ study.

6. Conclusion

Designing collaborative learning games may be one way to respond to the needs of working life in the 21st century. The synthesis of empirical research presented here suggests that games can provide a rich experience while individuals are engaged in complex decision making and the management of complex issues that might resemble cognitive processes employed in the real world (Spires *et al.* 2008). The literature suggests that games provide a valuable learning context in which the strategic management of complex problems can foster creative thinking skills and show individuals how their decisions have dynamic outcomes (Chiu *et al.* 2001, Squire *et al.* 2003). The role of collaboration within learning environments has been researched over a number of years and has been found to be particularly useful for learning to solve problems. Game design cannot ignore educational objectives, which should be included within the game in an interesting manner. This paper has explained the design process of CPS tasks that incorporate one of the 21st century skills and investigated the way learning can be combined into game design in a collaborative environment. In these games, learners combine knowledge from different areas to choose solutions or make decisions, and learn about the effects of their actions on the outcome of the game. At their best, well-designed multiplayer games enable engagement, communication and collaboration between individuals. Technology alone does very little to aid learning. Learning how the activities are structured, and the degree to which they provide learning scaffolds.

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Relationship Between Game Categories and Skills Development: Contributions for Serious Game Design

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Abstract: Recently, Serious Games (SG) achieved a recognized position as a learning tool in several contexts. SG provide constructive learning environments in which errors can be made without real life penalties and where students get instant feedback from their actions when facing challenges. These challenges should be in accordance with the intended learning goals and they should adapt and/or be repeated according to the learner's level. This aspect is decisive in the acquisition of knowledge, experience and professional skills through the simulation of different situations and contexts. The effectiveness of competences' training is directly related to the success in their acquisition but, above all, it is related to the ability to apply them to successfully perform a given task. However, an optimal game design methodology for competence training is yet to be created. This article presents a study that identifies the most appropriate game categories to develop specific skills and competences. It considers a taxonomy with eight game categories (Action, Strategy, Playing, Sports, Management Simulation, Adventure, Puzzle and Quiz) that were matched with the Education Competences and Educational Competency Wheel. Analysing 116 serious games allowed identifying which categories were more efficient in the training of a specific competence and therefore should be reused in the same scope.

Keywords: serious games, skills, competences, assessment, game type, game-based learning

1. Introduction

In recent years Serious Games (SGs) attained an increasing interest from many researchers on different fields such as psychology, cultural studies, computer science, sociology and pedagogy. It is clear that there is a growing focus on SGs demonstrated by an increasing number of conferences, companies, and publications devoted to the subject (Ratan and Ritterdeld, 2009). Although there is an acknowledgement of the great value of SGs in education and of the potential benefits of using digital games to engage learners and to improve the learning effectiveness, there is still little insight on the possibilities of using SGs in the particular context of competences' training.

Our aim with this paper is precisely to offer a contribution to identify the most appropriate SGs game categories to ensure the successful training and certification of skills. The paper considers a taxonomy of eight game categories (Action, Strategy, Role-Playing, Sports, Management Simulation, Adventure, Puzzle and Quiz) and relates it with standard competences and skills through a referential competences model as "a collection of competencies associated of the necessary attributes, behaviour, areas of knowledge, skills and abilities for a successful job performance"(Lombardo et all, 2005). This referential contains six core skill-sets and personality characteristics such as Individual Excellence, Organizational Skills, Courage, Results, Strategic Skills and Operating Skills.

This paper is composed of three main parts. Firstly, we expose some topic background in which several concepts are defined such as: Serious Games, Game Categories and competences training. The second part shows the method applied in the study, and finally, the third part presents the discussion of the results.

2. Background

Unlike the Commercial Off-The-Shelf (COTS) games, where the entertainment is the primary focus, SGs are driven by educational goals. These games are intentionally designed to help learning, skills acquisitions and attitude and behaviour change. The game design process becomes the key issue to ensure the achievement of the learning outcomes through the game play.

2.1 Serious games

SGs "are games insofar as they have rules, simulate behaviours, accept input from the player, and provide feedback within the context of the rules and behaviours" (Michael and Chen, 2006). This type of games is defined as "an interactive computer application, with or without a significant hardware component, that: has a challenging goal; is fun to play and/or engaging; incorporates some concept of scoring; imparts to the user skills, knowledge or attitudes that can be applied in the real world" (Bergeson, 2006).

Mike Zyda (2005) describes Serious Games as "a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives". However, the main emphasis on a serious game is still the educational purpose (Jegers and Wilberg, 2003) with focus on learning and training and the application of new pedagogies (Allen et al., 2009). According to Mohamed and Jaafar (2010), educational games put learners in the role of decision makers, receiving immediate feedback from their actions and decisions, inviting to exploration and experimentation.

The research of Freitas and Jarvis (2007) about Game-based Learning "shows some initial evidence of accelerating learning, increasing motivation and supporting the development of higher order cognitive thinking skills". The association of that with digital games, digital game–based learning, supports a new approach to learning because the player, which in the educational context is a learner, uses games to explore, discover, question and ultimately build concepts and relationships in authentic contexts (Yang, 2012).

This study also concluded that games helped learners to understand very complex concepts more easily and also increased their motivation through a positive association between the learner and his learning. In this work it was also concluded that "the advantage of serious games approaches lies in their ability to create dedicated content for learning purposes, rather than adapt existing leisure games to education practice".

Serious games are becoming increasingly more popular in the corporate level as well as in research communities. In spite of all this attention, there are still a lot of different definitions about what a serious game is. For this paper SGs are defined as follows: Serious games are applications which aim to take advantage of all the features that make games fun and engaging and use them to empower learning (Susi et al., 2007), promoting trainees interest by making the focused educational subject exciting.

2.2 Game categories

Games can be organized into categories defined by game play challenges (mechanics) rather than the visual or narrative styles. Understanding games' categories allows the game designers to appropriately match new content with a standard game mechanics and to expand in already established game mechanics (Adams and Rollings, 2006). The main factor that unifies a game genre is a similarity in the type of interaction that is supported between the player and the game (Pinelle et al., 2008). Therefore, this interaction corresponds to the game mechanics as actions of game objects and players during gameplay. These repeated actions or challenges are what define the genre of a game.

Overall, this type of game categories' classification can be seen as a subjective practice, and the number of accepted game categories has evolved in recent years as games become more sophisticated and diverse (Sellers, 2005).

In the investigation reported in this study, we use game categories that have been widely accepted in the video game industry, composed of eight types: Action, Strategy, Playing, Sports, Management Simulation, Adventure, Puzzle and Quiz. The following table presents the taxonomy, briefly describes each of the eight categories and it also includes several sub categories.

Table1: Taxonomy of game categories

Game Genre	Goals	Sub-Genre
Action	To win challenges against one or more opponents by engaging in a series of physical actions (timing (reaction speed) and accuracy are emphasized). Realism is not emphasized.	Beat' em ups, Shooter games (1st and 3rd person), Platform games

Game Genre	Goals	Sub-Genre
Strategy	Winning thinking challenges against one or more opponents by planning a series of actions (physical challenges are not emphasized)	4X (eXplore, eXpand, eXploit, eXtermine), Real – time strategy games, Real – time tactics, Turn – based strategy, War games
Role-Playing	Winning challenges with one or more opponents by planning a series of actions. Victory is achieved through planning/out-thinking their opponents (physical challenges and chance take a smaller role). Distinct from action games, RPGs seldom test a player's physical skill (combat is more tactical than physical) and involve other non-action game play (resource management)	Action RPGs, MMORPGs
Sports	Actions games where realism of movements and techniques are very important.	Exergames, Sport/ management games
Management Simulation	Winning finances challenges (without fighting) by planning a series of actions. Direct action upon an opponent is not emphasized. Typically, designed to be never – ending (no Win scenario). Goal example: to build a collection of objects.	Racing games/Vehicle, Virtual worlds/Pets, Life simulation/social games, Business
Adventure	Using an avatar for exploration in an interactive story and to win thinking challenges in isolation (puzzles) by planning a series of actions (physical challenges are not emphasized).	Graphics adventure, Puzzle adventure
Puzzle	Winning logic challenges in isolation (not around a conflict with another opponent) by planning a series of actions. Games usually involve shapes, colours or symbols that the player must directly or indirectly manipulate into a specific pattern.	Action/Arcade puzzle (timed), Reveal the picture game, Physics game, Traditional game
Quiz	Testing the knowledge of commonly used terms in a fun and friendly manner.	

2.3 Training and educational competencies standard

The competency is the capability to apply or use a set of related knowledge, skills and abilities required to successfully perform a desired task. Lominger's set of sixty-seven competencies (Constant Contact, 2014) became a universal common denominator as most of these competencies lead to task success. This assessment tool is called Leadership Architect Competences and permits to compose a list, using one or combining a few of the existing competency models, which encapsulates the competencies needed to succeed (Lombardo and Eichinger, 2005). This competency model represents "a collection of competencies associated with a successful performance" (Garman and Johnson, 2006). In order to apply it to education or training, the same authors created, together with Microsoft, a similar approach called Education Competencies or Educational Competency Wheel (Microsoft, 2013). This tool represents many of the necessary attributes, behaviours, areas of knowledge, skills and abilities for a successful job performance.

The table of competences, seen in Table 2, consists of six core skill-sets and personality characteristics such as Individual Excellence, Organizational Skills, Courage, Results, Strategic Skills, and Operating Skills. These categories contain 44 competencies of Lominger's standard, but can be extended to others areas outside of education, as competences' training. The competency wheel provides other resources to help identify the core competencies, which are the ones associated with the success of an organization (Garman and Johnson, 2006). These resources include a definition, four levels of proficiency, sample interview questions, activities and resources for developing skills in order to help an organization to achieve success.

The table presents the six qualities or success factors and their competencies. The factors can be divided into two categories: hard and soft skills. This categorization became usual. While the first are teachable abilities or skill sets that are easier to quantify, the others are subjective skills that are much harder to quantify.

In this categorization, we can consider as soft skills the core skill-sets: Individual Excellence, Courage, Results, Strategic Skills, and as hard skills the others: Operating Skills, Organizational Skills. This group of soft skills provides the ability to achieve results by working effectively with others in various circumstances; the ability to speak directly, honestly, and with respect in difficult situations; an emphasis on goal-oriented action; and an array of skills used to accomplish focused, longer-term goals. As for the hard skills group, it provides an array of skills used for daily management of tasks and relationships; and the ability to communicate by various means within different organizational settings.

Table 2: Educational competency wheel (Microsoft, 2013)

Education Success Factors					
Individual excellence	**Organizational skills**	**Courage**	**Results**	**Strategic skills**	**Operating skills**
- Building effective teams (IE1) - Compassion (IE2) - Customer focus (IE3) - Humor (IE4) - Integrity and trust (IE5) - Interpersonal skills (IE6) - Listening (IE7) - Managing relationships (IE8) - Managing vision and purpose (IE9) - Motivating others (IE10) - Negotiating (IE11) - Personal learning and development (IE12) - Valuing diversity (IE13)	- Comfort around authority (OrS1) - Organizational agility (OrS2) - Presentation skills (OrS3) - Written communications (OrS4)	- Assessing talent (C1) - Conflict management (C2) - Managerial courage (C3)	- Action oriented (R1) - Drive for results (R2)	- Creativity (SS1) - Dealing with ambiguity (SS2) - Decision quality and problem solving (SS3) - Functional/technical skills (SS4) - Intellectual acumen (SS5) - Learning on the fly (SS6) - Strategic agility and innovation management (SS7) - Technical learning (SS8)	- Developing others (OpS1) - Directing others (OpS2) - Managing and measuring work (OpS3) - Managing through processes and systems (OpS4) - Organizing (OpS5) - Planning (OpS6) - Priority setting (OpS7) - Time management (OpS8) - Timely decision making (OpS9)

3. Methods

The methodology applied consisted on the collection of serious games in distinct sites such as: http://www.gamespot.com/, http://www.healthgamesresearch.org/db, http://www.gamesforchange.org/, as well as other open SG repositories, to obtain each individual game information like description, classification, domain area, game genre, topics, target and realism. When the game was available, it was also played to identify more clearly the competencies involved. The study considered 116 serious games and compared their competencies group with the extended game genre taxonomy.

The following table summarizes the game list decomposed into several categories and its sub categories (the whole list is available at: https://db.tt/Sl9JBACM).

Table 3. Summary of games by genre and sub-genre

Categories	Sub - Genre	Subtotal	Total
Action	Beat' em ups	2	8
	Shooter games (1st and 3rd)	1	
	Platform games	5	
Strategy	4X (eXplore, eXpand, eXploit, eXterminate)	1	8
	Real-time strategy	1	
	Real-time tactics	1	
	Turn – based strategy	4	
	War games	1	
Role Playing	Action RPGs	2	4
	MMORPGs	2	
Sports	Exergames	2	3
	Sport /Management games	1	
Management Simulation	Racing games / vehicles	6	41
	Virtual worlds/Pets	24	
	Business	8	
	Life simulation / Social Games	3	
Adventure	Graphics adventure	17	19
	Puzzle adventure	2	
Puzzle	Action/Arcade puzzle (timed)	14	22
	Physics game	4	
	Reveal the picture game	2	

Categories	Sub - Genre	Subtotal	Total
	Traditional game	2	
Quizzes		11	11

With the obtained quantitative results, in the following two steps were applied: Firstly, we have chosen the most relevant sub-genre of each game category and compared them. The results allowed measuring the distance between them. Secondly, the study focused on each chosen genre in comparison with all the skills in the Educational Competency Wheel. The results allowed concluding what the relevant skills were, as well as the sets of skills for different game genres. A few sub categories had no correspondence on the retrieved list of games. The categories which have more sub-genres unidentified were Action, with three (fighting, maze and rhythm action games), and Adventure, with two (text adventure and visual novel).

4. Results: Skills and game genre

This study aimed to identify the best genre, or set of categories, with the most appropriate mechanics and challenges for skills' learning and training. The following images show the proportional values of the greater sub-genre in each core skills-set. In the Individual Excellence, the study focused on the skills that provide the ability to achieve results by working effectively with others in various circumstances. The results showed higher prevalence of Role Playing Game (RPG) genre in several skills as: Negotiation, Building Effective Teams and Motivating others. Other skills are Valuing Diversity, Personal Learning and Development, Integrity and Trust and Interpersonal Skills. Other categories, such as Strategy, have relevant numbers, around 50%, in the majority of identified skills in RPG. Categories such as Action and Adventure can be useful in some particular skills: Negotiation and Valuing Diversity.

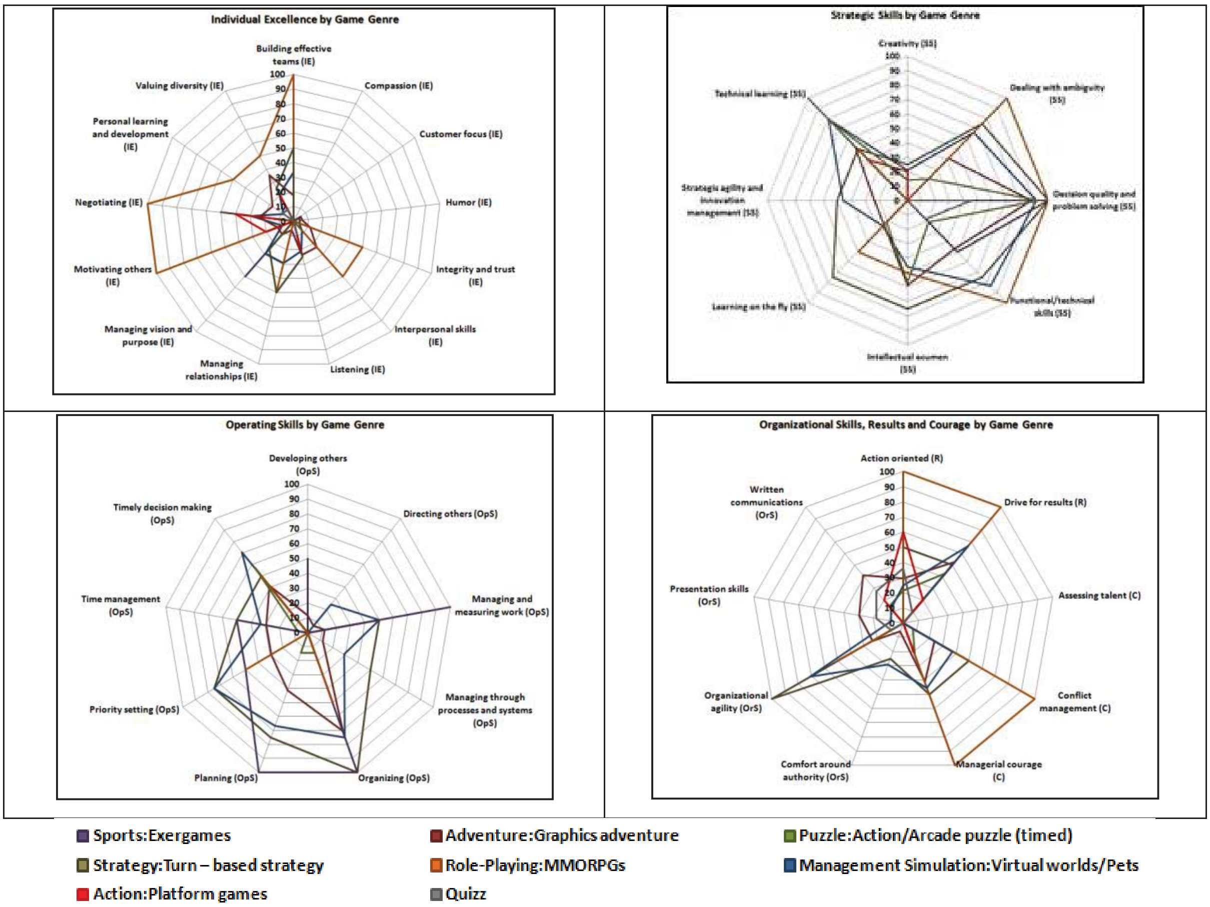

Figure 1: Core skills-set by game genre intersections

The second core skills-set refers to Strategic Skills, which provides an array of skills used to accomplish focused, longer-term goals, demonstrates that all genres are designed for Decision Quality and Problem Solving skills. The Functional / Technical Skills and Dealing with ambiguity have more emphasis with the following categories: RPG, Strategy and Management Simulation, while Intellectual Acumen and Learning on the Fly skills can be acquired through the RPG, Adventure and, preferably, Strategy genre. Quizzes, Puzzle and Management Simulation can improve the Technical Learning skill.

Operating Skills, which are responsible for the ability to communicate by various means within different organizational settings, have as predominance of Sport and Strategy categories. Management Simulation has some relevance (higher 60%) in several skills, such as: Timely Decision Making, Priority Setting, Planning and Organizing. Finally, the Adventure genre can be used in organizing skills and to acquire the skills: Organizing, Priority setting and Timely decision-making should be applied to the RPG genre.

Last but not least, the final investigation graph is a three in one. So, it is important to mention that the RPG genre is almost absolute in the skills-set Results and Courage. Even then, the Strategy genre is more appropriate for the Organizational Agility skill, as well as having some relevance in the Results skills: Action Oriented and Drive for Results, several categories, Action, Adventure and Management Simulation.

The second approach of the study aims to analyse each genre as a whole and check what the most impact areas of the skills acquisition are. The following images are grouped, in most cases, by similar patterns identifying skills as indicated by references that can be linked with Table 2. The graphic choice, spider graphic, seemed most appropriate because it shows the reasonable limits of change for each independent input and the unit impact of these changes on the outcome.

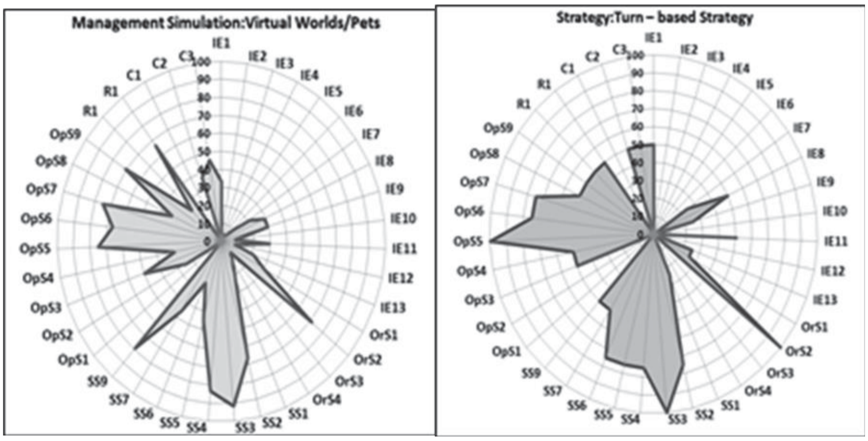

Figure 2: Graphics of identified skills in management simulation and strategy categories

Figure 2 shows the Management Simulation and Strategy categories. These categories have similar impact areas for training skills such as Results (R), Operating (OpS), Strategic (SS) and Organizing (OrS). More specifically, the impact of organizational agility (OrS), quality and problem solving (SS), and organizing (OpS) are stronger. Others diverse skills from Operating (OpS), Strategic (SS) and Organizing (OrS) need to pay attention because this relevance is over 60%.

Finally, it should be noted that both categories haven’t any relevance into Individual Excellence Skills-sets, although the analysed sub-genre is virtual worlds and not business.

The next image (Figure 3.) shows the Adventure and Sports categories. The first genre demonstrates more predisposition for particular skills of several skills-sets. For instance, it is relevant in Organizing (OpS), Intellectual Acumen (SS), Functional/ Technical skills (SS) and particularly, Decision Quality and Problem Solving (SS). The Drive for results (R) skill is relevant in both categories with results of 50%. The Sport genre presents a curious map because the results identify the most appropriate skill (100%). One of the reasons is the lower number of reviewed games. However, that indicates the most relevant are Managerial Courage (C), Organizing (OpS), Planning (OpS), Managing and Measuring Work (OpS), Decision Quality and Problem Solving (SS) and finally Organizational Agility (OrS).

The others identified skills obtained 50% of relevance such as: Action Oriented and Drive for Results of Results skill-set, Valuing Diversity (IE), Developing Others (OpS), Priority Setting (OpS) and Time Management (OpS).

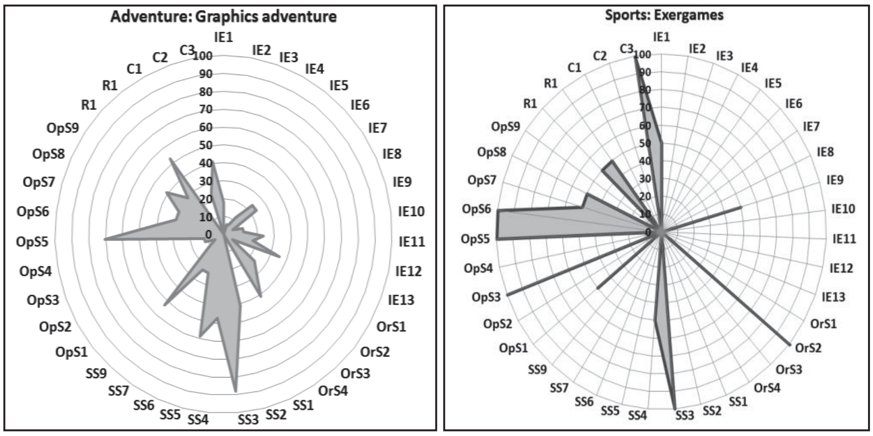

Figure 3: Graphs of identified skills in adventure and sports categories

The Sport genre is one of the cases in which it is necessary to increase the number of games analysed, to improve the relevancy of previous results. In this study, the sample considers only two games, as well as one genre, included in the following image (Figure 4.), Role Play Games.

This image shows the Action and Role Play Games genre. It is relevant to verify, about these two categories, that the first genre, Action, is most important in Action Oriented (R). However, other skills have impact like Decision Quality and Problem Solving (SS), Technical Learning (SS) and Negotiation (IE), even with 40% of relevance. The RPG genre is relevant in several skill-sets like Results and Courage. The most important aspect is many of Individual Excellent skills that obtained significant values between 50% and 100%. This result makes it the most appropriate genre for training these soft skills.

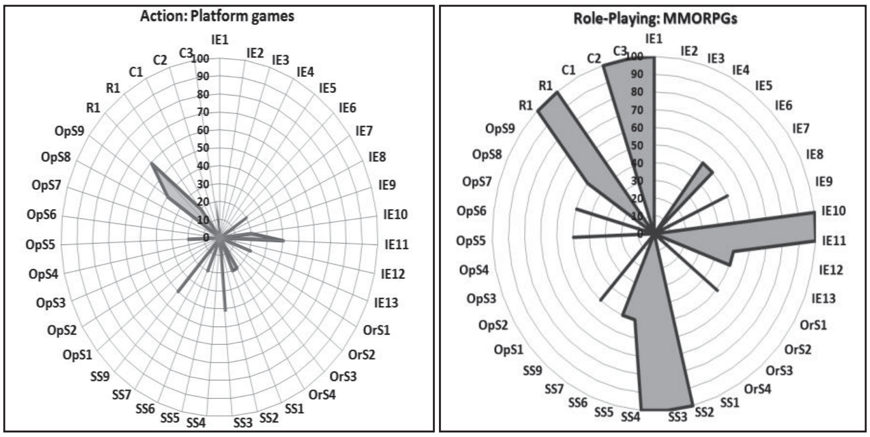

Figure 4: Graphs of identified skills in action and role-play categories

In the latter genre, the impact of other skill-sets occurs because of Strategic Skills with the following skills: Dealing with Ambiguity, Decision Quality and Problem Solving, and Functional/ Technical skills. Some other elements from Operating Skills can contribute for successful abilities' acquisition such as Organizing and Priority Setting.

Finally, the last graphs image (Figure 5.) compares the Puzzle and Quiz categories.

For the Quiz genre, the most important conclusion is to identify the most suitable skill training as Technical Learning. In what concerns the Puzzle genre, the most relevant skill-set is the Strategic Skills with the stronger contribution for Decision Quality and Problem Solving, Technical Learning and Intellectual Acumen; but, in this last case, with only 60% of relevance. The Puzzle genre shows some capabilities in the Time Decision Making (OpS) skill.

The graph results show how each game genre has different impacts in skills training, as well as help the identification of the best genre in order to achieve the learning outcomes. Nevertheless, in many situations, the best choice can be a mix of game categories that take advantage of the most appropriate skills to complete a particular learning outcome or ability.

These diverse maps work as an interesting tool for math games, to train competences. But for that goal, it is necessary to have a continuous update of the survey to achieve the increment of revised SGs. Another important aspect is to enrich some of the game categories with more games because, on the one hand, the results achieve more diversity and data consistency related to the genre and its sub-categories with a wider range of games; on the other, to improve the quality of the global results.

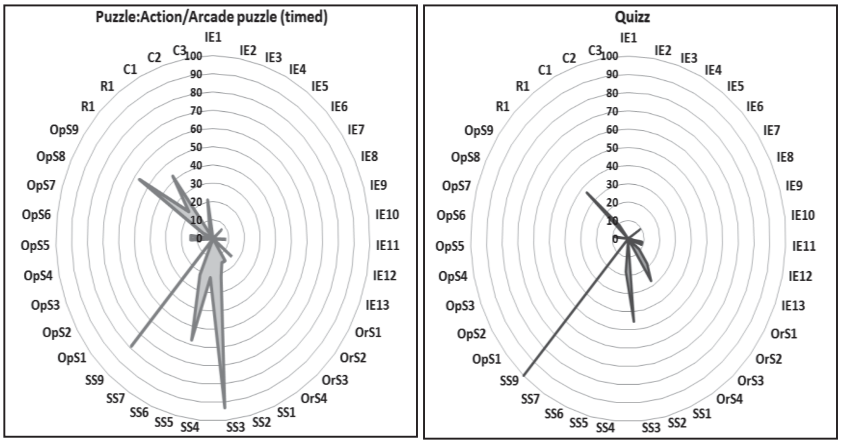

Figure 5: Graphs of identified skills in puzzle and quiz categories

One last note: this genre study reflects only on the sub-genre with more occurrences and it is not a generalization by genre.

5. Discussion

Having identified the skills which are present in the eight game categories previously mentioned in Figures 1-5, we can use this knowledge to improve serious games.

The potential of the distinct game categories to support skills' learning is extremely important and contributes to the development of wide variety strategies of the game design. This contribution can result in a mix of game categories or reinforcement of challenges to achieve skills such as: Decision Quality and Problem Solving and Technical Learning (SS); Organizing and Timely Decision Making (OpS); as well as both skills results (Action Oriented and Drive for Results) can be synchronized with different strategies to get better learner performances.

Unfortunately, the overall results of Individual Excellent skills were not significant. That situation demonstrates which are the more difficult soft skills or personal development issues either to train or to measure to improve new skills. Exceptionally, the Role Playing Game genre has several contributions in group strategies such as cooperative work (Building Effective Teams (IE), Motivating Others (IE) or Conflict Management (C)).

With the game categories defined in section 2, using the method presented in section 3 and the skills identified in the previous section, the following question arises: what are the learning and training benefits which can be achieved through the implementation of serious games?

The benefits identified show that the experience is the most important aspect of serious games, and that the performance can be improved through a set of challenges. Frequently, using mechanics from one genre isn't enough to support the goals of skills training, but this work demonstrates that the game designers have several choices to get to the best skill learning. A further boost should be given to the implementation of serious games to skill training if the training experience is set from a game structure (actions/ challenges), as well as each defined challenge can be used independently, or not, for the improvement of different skills.

6. Conclusions

The results of this survey lead us to identify some areas with significant intersections between the game categories and competences. The crossing analysis applied helped to define comparatively the most significant genre in each core skills-set, and showed how each genre can contribute in several skills training.

These sets of maps demonstrate the strong correlation and impact between some game categories, such as adventure, sport, strategy and management simulation, and some hard skills (organizational and operating) and soft skills (strategic and results). A hardly surprising result is the lower impact of most game categories for the core skills-set of Intellectual Excellent, with the exception of Role Playing Games.

Another conclusion from the results is that they can be applied as a reference for different training contexts or domains areas; as well as being useful to understand these previous experiences, and being able to provide hints for the game designers to develop new SGs.

In the future, this study will be continuously updated with the investigation of new releases of SG, in order to improve the best game genre identification, to achieve the desired learning outcomes. This contribution may eventually be developed as game categories vs competence and skill matrix.

Acknowledgements

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Conflict Resolution of Game-Based Learning: When Teacher-Centered Approaches Need to Supersede

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Abstract: While many educators and academic institutions are moving towards the switching of the traditional teacher-centered approach of instruction to a more liberal and "democratic" form of learner-centered approach to learning, there may be organizational issues affecting some parts of the transition. In particular, while some programs of study want students to become more engaged and motivated in their learning activities within the classroom, some may not have the necessary education or training to see the relevance of some learning activities over the use of others. A literature review was focused first on what is Games-Based Learning (GBL), in terms of the imagery of some archaic video games or mindless wonder (time filler) activities may be in the forefront of some educators or academic administrators. However, there is a growing piece of literature that has showing that a varied approach to learning, as well as teaching, can help to encourage, motivate, and engage more adult learners not only to participate more in their academic endeavors, but also may increase the likelihood of more student retention. While adult learning may also be focus on the accomplishment of certain class learning objectives, perhaps the learning objectives, syllabus, and overall classroom design and layout need to be re-evaluated to see if it is meeting the needs of today's adult learners, as well as offering a more enhance learning environment to engage and motivate more adults. Therefore, the use of Games-Based Learning offers a chance for more instructors to update their classroom layout and delivery of course content, as well as demonstrating to the student that despite various organizational issues and potential setbacks, the instructor is showing a level of interest in the student not seen in previous decades with a more "focused' approach to engage the learner and facilitate a "different type of learning environment" with a more modern-day approach.

Keywords: game-based learning, adult learning, online learning, learning activities

1. Introduction to games-based learning

The transition from a physical teaching environment, known as a Face-to-Face (F2F) learning environment, over to a more modern and technology-based applications approach, known as a virtual learning or online learning environment, both teachers and students may face some difficult challenges. While these challenges may present themselves at any time during the transition process or during or after it, the learning process needs to happen and measurable academic success/achievement needs to be evidenced. Students still needs some time of reinforcement that they are on the right track and also need to know that they are working towards a purpose that will meet their needs and that of the course requirements. (Chalfofsky, Rocco, Morris, 2014). On the other hand, we have to consider the end result and how the students will use their education in the real world of work. According to Barbara Smith (2000), chief learning officer for Burson-Marsteller stated that "If we don't have the best people creating the best product, we can't compete. What I'm after is creating the best people in the industry. E-Learning is an option that provides us with real competitive edge – it helps us maximize our intellectual capital" (Koprowski, 2000, pg. 1). Further, technology is breaking down current knowledge barriers and practices about work processes and learning. However, one of the key obstacles has been the lack of recognizing the effect of errors and changes in an organization in terms of learning and to create more knowledge for the organization. Perhaps educators need to rethink their approaches to learning and consider alternative ways of teaching and engaging today's adult learners.

2. Literature review

A literature review was focused first on what is Games-Based Learning (GBL), in terms of the imagery of some archaic video games or mindless wonder (time filler) activities may be in the forefront of some educators or academic administrators. However, there is a growing piece of literature that has showing that a varied approach to learning, as well as teaching, can help to encourage, motivate, and engage more adult learners not only to participate more in their academic endeavors, but also may increase the likelihood of more student retention (Barrett, 2007; Barrett, 2011, Barrett, 2014). It should be noted that a traditional literature review was not a key component here, but more discussion was given to various parts of the literature. In fact, games have been viewed traditionally over the centuries to be linked to pre-formal learning and forms of physical activity. As we move from this archaic perspective to a more modern approach to games-based learning, we are moving from the traditional approach to learning to a more non-traditional approach. Therefore, even our literature reviews and research methodologies need to change in accordance to this novella approach to another form of learning. When one thinks of Games-Based Learning (GBL), the imagery of some archaic video games or mindless wonder (time filler, as some think of this type of interaction), these activities may be in the forefront of some educators or academic administrators. Nonetheless, there is a growing piece of literature that has showing that a varied approach to learning, as well as teaching, can help to encourage, motivate, and engage more adult learners not only to participate more in their academic endeavors, but also may increase the likelihood of more student retention. However, we have to think about learning in general and what we know and how we can rethink how it is done and shared. In order to move from the traditional form of learning with set learning activities, today's educational systems are incorporate more technology and a need for more teachers with a certain mindset (Senge, 1990) in order to understand both the needs of the adult learner, as well as the educational requirements necessary for the student to master the need skills and experiences to accomplish the give learning objectives. Without some sequencing of learning, the learning with game-based learning may be lost in its time and place and not an ongoing type of learning achieve. Historically, the thought of video/arcade games was seen as a frivolous and non-mind intense skills, as well as the line of reasoning of the use of computer games – just time filler seen by many. However, with the onset of educational games that required the teacher to learn some programming, such as the Logo computerized learning software that required the instructor to have a basic knowledge of logo programming, the software was useless if not programmed correctly. While this earlier forms of gaming software was seen as cumbersome by main, earlier pioneers of educational technology saw this a change in the learning mindset and a new plateau to be achieved for more enlargement of the learning process. According to Van Eck (2006), "Digital gaming is a $10 billion per industry, and in 2004, nearly as many digital game were sold as there were people in the United States (248 million games versus 293.6 million residents)". (eSchool News Online, 2005; Entertainment Software Association, 2005).

As the software packages continued to improve and more teachers and administrators bought into the "educational technological evolution", some educators still clung to the traditional form of teaching via the blackboard and chalk method. However, many of them were not quite ready when they heard of the new white board and eventually the use of an electronic blackboard to be capitalized and marketed throughout the world through a company called Blackboard (Bb). However, let us take a quick historical look at this term and how it has evolved and helped to engage more learners. According to Buzbee (2014), "Although the term *blackboard* did not appear until 1815, the use of these cobbled-together slates spread quickly; by 1809, every public school in Philadelphia was using them. Teachers now had a flexible and versatile visual aid, a device that was both textbook and blank page, as well as a laboratory, and most importantly, a point of focus." (para. 2). As technology changed, the teaching tools and strategies used by instructors also changed. According to Blackboard, Inc. (2015), it was "formed by the joining of two companies: CourseInfo LLC, founded by Daniel Cane and Stephen Gilfus, and Blackboard LLC, founded by Michael Chasen and Matthew Pittinsky. Originally, the Blackboard Company began as a consulting firm contracting to the non-profit IMS Global Learning Consortium. In 1998, it merged with CourseInfo LLC, a small course management software provider that originated at Cornell University. The combined company became known as Blackboard Inc. The first line of e-learning products was branded Blackboard CourseInfo, but the CourseInfo brand was dropped in 2000. Blackboard went public in June 2004. It operated publicly until Provident Equity Partners purchased the company in 2011. As of January 2014, its software and services are used by approximately 17,000 schools and organizations in 100 countries." (para. 4). As this company grew, learning for all types of adults from K-12, including university students started to learn from a different approach to learning by the utilization of a Learning Management System (LMS). Here are some facts about Blackboard,

- World Reach. We serve over 19,000 clients in 100 countries, including 1,900 international institutions alone
- Top education institutions. Out of the Top 50 Times Higher Education Reputation Ranking in 2014, 80% of the world's top academic institutions work with us.
- K-12. Our solutions and services are used by 1 in 3 U.S. school districts, including 70 of the largest 100 districts, and serve over 20 million K-12 students.
- Online bachelor programs. We support and work with 92% of the top online bachelor degree programs. (Blackboard, 2015, para.4)

For the purposes of this paper, we have outlined a historical context of the evolutionary change of one instructor tool, namely the blackboard, in order to understand how past teaching tools have been carried over to the virtual learning environment (Barrett, 2014; Barrett, 2011). Further, while we have seen the migration from the traditional chalkboard (slate) to a more virtual blackboard, we have seen greater opportunities for more learning activities to be created and designed for all types of learners. In particular, whether the online learning environment uses various "well-known" LMS or a proprietary-designed LMS, the goals are the same – to delivery content knowledge, offer a variety of learning activities, and offer some type of measurement of learning to determine if the learner is achieving the intended learning objectives.

Despite the type of technology being used or considered, the type of subject matter may have an impact on the learning experience. Further, as many academic institutions are moving from the "teacher-centered" approach to a "student-centered" one, the subject matter will be the same, but the type of learning activities, as well as the way it is approached and delivery can make a difference in the education of today's learners. Even though some learner-centered activities may work on certain classes and programs of study, some variety may be need to be offered from the instructor with a "teacher-centered" approach in order to ensure that all students are working on the same level of classroom participation, as well as engaging and motivating with everyone and only a select few. (Barrett, 2007). Thus, adult learning may also be focus on the accomplishment of certain class learning objectives, perhaps the learning objectives, syllabus, and overall classroom design and layout need to be re-evaluated to see if it is meeting the needs of today's adult learners, as well as offering a more enhance learning environment to engage and motivate more adults. However, while education has been evolving, as well as technology changing, the underlying question that has been lurking in the minds of many adult learners is why go on with additional education, such as college, if the earlier years of education in high school were so horrible and daunting? Many adult learners may be wondering whether not to entertain the thought of future torture, torment, and endurance in order to obtain a degree that may or may not help one to achieve additional earnings, better career advancement and/or job satisfaction? Nonetheless, education be fun and entertaining for both the learner and educator. Equally important to note is that academics can help to provide the best possible education and engage today's learners who want to continue onward with their program of study. Studies have shown that the use of game-based learning have helped to engage students, but how the game-based learning is presented is equally important (Kapp, 2012). As we progress to the next segment of the paper, we will continue with the point of instruction in order to build a contextual overview of considerations given in the light of newer instructional methods and technology.

3. Traditional teaching strategies and approaches for teaching course content

Historically, many instructors have use the Socratic Method of instruction, usually as required by the educational institution or administration. Learning has changed since the days of Socrates demonstrating his own form of teaching, which is known was the Socratic Method. This method served as the foundation of the earliest form of the teacher-centered approach, however, this is now movement to move towards a more "adult centered" or now known as the learner-centered approach. (Barrett, 2014). With this specific method of instruction, including both the F2F and online learning environments, the administrators and online course designers being tied to this heavily used method of instruction (but sometimes limited in its application of certain course content). As a result, education and learning has been stigmatized and frozen in a vacuum in some learning venues. However, some adventurous and progress types of educations have tried more methods of instructions, namely, the use of video games as a form of instruction has proven helpful in some types of learning environments, but not with all types of adult learners. While this type of methodology is good for lectures and demonstrations, but for the purposes of this paper, it will be used as a starting point for delivery instructions prior to the use of game-based learning.

Thus, this leads to the question of whether game-based learning is needed in today's learning environment or not? Knowles (1980) noted that "adult [learners] see education as a process of developing increased competence to achieve their full potential in life. They want to be able to apply whatever knowledge and skill they gain today to life more effective tomorrow." Therefore, we are seeing more working adults seeking further education, but what are their learning needs for the short- or long-term? The key question here is simple – can educators in today's harsh economic times afford to be hard-pressed to traditional rules or rules and educational methodology or will they need to change with the times in order to meet not only the needs of today's adult learner, but also the needs of the business community and society in general? Can the business community command enough attention for changes in the educational programs of today's educational institutions or does society have to warrant a need for change for today's educators to meet the needs of a much shrinking workforce and growing number of Baby Boomer retirees?

These questions for not only consideration and reflection, but these questions are focus on some hard-pressed societal and business issues and needs. What educational institutions do next will determine upcoming trends in both the workplace and marketplace. However, it should be note here, that perhaps companies like Microsoft, Google, and Yahoo have it made – because they use the theories in use approach as opposed to espoused theories and hope for change. Can you image where Google would be today if they did not take a change in technology and make their workplace fun for the employees? The question in point here is why is innovation and creativity so important with some of these companies?

4. As technology and demographics have changed the needs of the workplace and education

As technology changes, educational needs and offerings also need to change or be changed as a result of the evolving-technological movements in today's marketplace and work environments. During the past decades, the demographics of learners has been changing, especially with students with disabilities. Since the passages of key federal mandates in the United States, in particular, the Americans With Disabilities Act of 1990 ("ADA"), we have seen more students enrolling into courses. In the United States, the passage of the Americans with Disabilities Act of 1990 (ADA) help to change and correct many factors and circumstances affecting the lives of these individuals. Specifically, it provided a federal mandate compelling organizations, in particular in the field of education, to make changes in how it made accommodations for learners with disabilities.

Consequently, while this federal mandate has been in effect for two decades, some universities and their instructors still have not brought their courses up to par. As a result, this federal mandate has caused many universities and their various departments to set up either to address the various learning needs of "all" students or perhaps perish as more students start to gravitate towards more popular and accepting universities. According to the Disability Status 2000, Census 2000 Summary File #3; and Census 2000 Brief (March 2003)[5] (C2KBR-17), the following statistics about the employment of people of disabilities was noted: "The total number of people with disabilities aged 16-64 is 33,153,211, [of which], the total number employed is 18,525,862. The percent of people with disabilities aged 16-64 employed is 55.8" (Census, 2000, para. 4-6). Further, the reports went on to noted that "18.6 million people disabilities employed aged 16-64, 60.1% of men with disabilities are employed, and 51.4% of women with disabilities are employed" (Census, 2000, para. 7). Why is this important in the context of games-based learning? Simply, one commonality that many learners, with or without disabilities, have is the excitement of trying new technology or simply challenging their ability to learn and try new things (Barrett, 2014). Historically, many learners with disabilities would have to avoid programs or courses involving engineering, computer science or mathematics, depending on the type of disability they had. However, with this changing technology, more creative learning advances are paving the way for these individuals with psychomotor or mental challenges, as well as helping them to take more "control" over their learning abilities and skills.

It should be noted here is that not all adults learn the same and that they have different learning styles. Kolb (1984) "believed that our individual learning styles emerge due to our genetics, life experiences, and the demands of our current environment. In addition to describing four different learning styles, Kolb also developed a theory of experiential learning and a learning style inventory." Basically, not all students learn the same, and their level of interest and motivation may vary according to these various factors affecting their learning style. Cherry (2015) noted that if we look at Kolb's learning theory in which "learning is viewed as a four-stage cycle. First, immediate and concrete experiences serve as a basis for observation. Next, the individual reflects on these observations and begins to build a general theory of what this information might mean. In the next step, the learner forms abstract concepts and generalizations based upon their hypothesis. Finally, the learner tests the implications of these concepts in new situations. After this step, the process once again cycles back to the first stage of the experiential process." Many educators can identify one of the cause for the reluctant move towards education for many adults may be related to earlier learning experiences that caused a form of distrust or what Erikson called "mistrust versus trust" (Knowles, 1980).

5. Why teaching and learning practices need to change

First, as more educational institutions move towards more technological enhancements and online learning options, the need to design, develop, implement, and evaluate a number of different practices and procedures in order to prepare all students, especially learners with disabilities, to compete for quality and meaningful employment. Second, another need why more and more programs of study, such as computer science, need to update their courses with better technology and policies in order to better defend oneself, both in and out of various learning environments. Therefore, the rate that many high-tech companies have expanded has also caused an increase in the number of school being able to require the best students with top degrees, as well as develop a new social order of learning in which the learner has more control over the learning environment (live or online learning environments) (Barrett, 2014). Consequently, as more educational institutions obtain more technology, they realized that one important element of learning that affects the technology is the need for socialization and interaction. According to Preece (2000), these online communities "consists of people who interact socially as they strive to satisfy their own needs or perform special roles; a shared purpose that provides a reason for the community; policies that guide people's interactions; and computer systems to support and mediate social interaction and facilitate a sense of togetherness" (p. 10). (as cited in Barrett, 2011).

While more colleges and universities have been focused on the needs of business and industry to not only attract more corporate clients, but also to regain the confidence of many people who might have foregone the idea of continuing their education. Educators need to look beyond their current scope of doing things and perhaps look at other models. Thus, if we look at the business side in terms of understanding various other approaches and strategies in business, we might look at the works of Weisbord and his model. Again, if we look at a historical point of business modeling, we might be able to apply this type of model to a potential application in today's workplace and educational setting. Weisbord (1976) created a framework of a six-box model that can help one to examine how an organization functions. Consequently, this particular model has been used by many organizations in order to diagnosis various segments of organizational life. Whereas, it is based on various assumptions and techniques used in the field of organizational development, but yet, it still has a good functionality over the past several decades. In particular, Weisbord's six-box model consists of the following boxes:

- Purposes: What 'businesses' are we in?
- Structure: How do we divide up the work?
- Relationships: How do we manage conflict (coordinate) among people? With our technologies?
- Rewards: Is there an incentive for doing all that needs doing?
- Leadership: Is someone keeping the boxes in balance?
- Helpful mechanisms: Have we adequate coordinating technologies?

Educational institutions, just like businesses, need to scan their environment continuously to see if they are reaching not only their immediate goals, but the future needs of their audience (learners). Thus, this brings the main thrust of the paper back to the over-arching question of what approach can educators take to be creative in implementing a new type of learning activities, specifically a game-based approach to learning. One of the most popular games is an American game show know as Jeopardy. Further, the use of this popular TV show quiz format has helped to measure learning outcomes/content knowledge, serve as a learning activity to engage the adult learner, and develop a sense of socialization and competitiveness among the learners. From the point of creation to development and implementation, this process has served as a basis for creating not only best practices for incorporating more interactive learning activities, but also as a foundation for memorializing lessons learned and share them with other academic members (Barrett, 2007). This quiz format learning activity will be used with graduate-level learners in the context of reinforcing their content knowledge gained through readings and other learning activities. This preliminary use of this learning tool will be used in a beta testing context with the instructor observing the level of interaction. Thus, the following discussion will outline how to create one's one version of Jeopardy for classroom inclusion, along with discussion of the implementation process.

Step 1: Educators can conduct an Internet research on the various uses and model applications of the Jeopardy quiz format to be used as one's model for classroom use. Here is a sample list of websites for review and possible use:

JeopardyLabs (2015) – retrieved from https://jeopardylabs.com/

Apache Open Office (2015) retrieved from http://templates.openoffice.org/en/template/jeopardy-quiz-template

JeopardyApp (2015) – retrieved from http://www.jeopardyapp.com/

Step 2: Now that one has the template or application loaded up, you need to decide on your content material. Are you using this approach to learn content for a unit or chapter? Or are you preparing students for an upcoming quiz or exam? Finally, are you using this game-based approach for engaging and motivating more participation from your learners?
Step 3: Since the intent and materials are decided upon, we need to develop a "better practice" and write out the questions and responses that will engage the learner to draw upon one's own current knowledge or help drive the learner to seek additional information and knowledge. A good practice is to have the student given a practice-quiz in class and build up the possibility of teams competing against each other. This is a way to work on "team building better practices" as well as strengthening study and communications skills in the interim of preparation for the upcoming event.
Step 4: Finally, prior to the use of any game-based learning should be some form of testing to see what is the reliability and validity of the material being measured. Another "better practice" might be to gather other instructors teaching the same subject or course material to try out the game-based learning. Not only can you gather more insight in terms of validity and reliability – it might help encourage the other educators to use this type of game-based learning.

6. Concluding points

It should be noted that not all learning activities may engage or motivate today's adult learners. Also, instructors may need to "think outside of the box" and try new approaches to teaching all types of adult learners. As noted previously, the potential use of well-known TV quiz programs (i.e., Jeopardy), movies or media-related events may help instructors to engage and motivate today's adult learners. As noted earlier in this paper, some learners may be reluctant to engage in course activities and overall participation as a result of earlier learning experiences. Consequently, if educators think of earlier years of instruction and perhaps single out one particular form of learning activities that engaged even themselves as learners, they may also agree that some form of game-based learning was also beneficial in their earlier years of instruction. There may be a good chance that if they use this approach with game-based learned that they may be able to regain the confidence and trust of new learners and help to erase previous educational experiences of mistrust and replace it with a more proactive form of self-confidence and trust, as well help these adult learners to re-discover the joy of learning and growing.

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Designing Location-Based Gaming Applications With Teenagers to Address Early School Leaving

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Abstract: Early school leaving (ESL) is an urgent and serious problem, both for individuals and society as a whole. Factors such as learning difficulties, social problems or a lack of motivation, guidance or support all contribute to ESL, although the situation varies across EU countries. High rates of ESL are detrimental to making lifelong learning a reality and increase the risk of unemployment, poverty and social exclusion. Since normally there is not a unique reason for leaving education or vocational training, answers are no easy. In response to these concerns, the Code RED project (http://www.codered-project.eu) has been created to address the high proportion of drop out from Initial Vocational Education and Training (IVET) and ESL in the UK, Greece, Italy and Cyprus via the development of new games-based learning applications (both desktop and mobile) to inform young adults (aged 16+) of the issues surrounding ESL. Location-based gaming (LBG) applications represent a form of play that is designed to be undertaken on a device in motion which changes the game experience based on the location. The design of these products presents many challenges to developers surrounding user interfaces, processing power and the availability of space. The ARIS platform (Augmented Reality and Interactive Storytelling) covers a broad field of LBG design components such as geo-location data, location-sensitive informational objects, interactive dialogues and QR code input. As such, ARIS has been selected by Code RED researchers to teach LBG and mobile augmented reality design concepts and prototype new design ideas with young adults. This paper will discuss the issues which are contributing to ESL within the EU and report upon the results of a short term participatory design initiative within Code RED to co-design new location-based gaming applications with participating IVET students (aged 14+) to address these issues. In the UK, participating students were successful in formulating a game concept suitable for transfer into LBG surrounding lifestyle choices such as alcohol and drug abuse which may contribute to ESL. In Greece, participating students with learning disabilities were successful in creating a fictional 'solve the mystery' LBG using the ARIS platform. Students decided to focus the game's narrative on the issue of exclusion from school and jumping into fast conclusions during schooling years. In Italy, participating children were successful in designing an orienteering-based LBG to promote cultural heritage via exploration of an ancient castle. This process also enabled participants to research and learn more about this local landmark. The paper will discuss the application of the participatory design methodology between project partners and will document the LBG output from this process. Finally, the paper will identify how these products will be positioned as part of future work to address ESL.

Keywords: location-based games, participatory design, employability, early school leaving, ARIS

1. Introduction

Early School Leaving (ESL) and drop-out from initial Vocational Education and Training (IVET) comprise major challenges in EU education systems, especially in relation to meeting employment targets. In response to these concerns, Code RED project (http://www.codered-project.eu) has been created to address the high proportion of drop out from IVET and ESL in the UK, Greece, Italy and Cyprus.

Preliminary work has involved an analysis of stakeholder needs to identify the major characteristics of ESL and disengagement from education. This process was conducted with key stakeholders in the four partner-countries representing the relevant categories of i) school principals, ii) teachers and trainers, iii) support staff including those responsible for ICT development iv) employment representatives, v) government representatives vi) youth and social centre workers, vii) university departments, as well as, viii) students themselves. The information was collected using pre-defined tools and instruments, with regard to the preferred and most effective ones for each stakeholder including one-to-one interviews, focus groups, email exchange were the main tools adopted to gather relevant information (Ariana et al., 2014).

1.1 Factors contributing to ESL in Greece

According to qualitative data drawn from interviews with educators, school directors and administrative staff in private and public secondary education schools in Athens, the main educational issues affecting the early dropping out of School and/or VET are family and teachers indifference towards the student, lack of specialized staff and experts in the school premises, old and de-motivational educational systems based on exams as well as the highly stressful workload for the students. The majority of the interviewees highlighted the inadequacy of the educational system to successfully integrate and motivate students with emotional, psychological and behavioural difficulties as additional contributing factors. Both in focus groups, interviews and questionnaires it was highlighted that students with educational difficulties or cognitive disabilities are not easily or promptly assessed and diagnosed, leading most of them away from the educational and vocational training process, while adding extra psychological pressure and lack of self-esteem. Students with intellectual and learning difficulties stated that they sometimes feel they would like to abandon school because of bullying and feelings of inadequacy.

In summary, there is no single policy framework on ESL in Greece. Instead, the ESL agenda is being taken forward within government programmes where three axes are devoted to 'upgrading the quality of education and promotion of social inclusion' in each Greek region. The programme encourages access to and participation in the educational system for all individuals and aims to combat ESL.

1.2 Factors contributing to ESL in the UK

Based on interviews with development officers working within community trust organisations that provides employability workshops and advice for young people classed as 'Not in Education, Employment or Training' (NEET), it was confirmed that lack of confidence, financial reasons, lack of work experience, language issues, communication/social skills, disability, lack of motivation, historic/generational (parents dropped out) cultural expectations, teenage pregnancy, drugs and gangs are all reasons why young people become disengaged from education. Based on discussion with such vulnerable adults, contributing factors to an individual's status as NEET include peer pressure, poor educational experiences, living circumstances (relating to transient nature of students in supported living accommodation), pressure from family to acquire work and earn money and a general lack of interest in education and schooling.

Regional strategies identified to combat ESL in the UK include 'Studio Schools' (a new type of state school model that has been developed in partnership with local and national employers, leading education agencies and government) designed to equip young people with the knowledge, skills and experiences they need to succeed in life and work. Such initiatives offer alternative curriculum programmes which work with pupils that are identified as being most at risk of leaving school with few qualifications and becoming NEET and aim to target young people before they drop out of the system to help them in realising their potential. These initiatives often use environments outside of the traditional classroom context to help re-engage pupils. Alternative curricula and innovative initiatives offered by different providers are all considered to be beneficial by both the young people and UK stakeholders with high levels of positivity being displayed towards the Code RED project and its aims.

1.3 Factors contributing to ESL in Italy

While confirming the key problem with ESL and drop out (Italy showed in 2014 the highest percentage at EU level), the needs analysis process conducted with the major Stakeholders (Professional Higher School Principal, Teachers and Trainers, those Responsible for Student dialogue and ICT development of local Minister of Education, Employment representatives, the Emilia-Romagna Region Responsible for School-VET joint policies devoted to ESL and drop-outs, the head of the major local NGO working in education sector in many schools, youth and social Centers, community-based projects) led to the following further considerations, based on the experience of addressing ESL and dropping-out in the Provincia di Parma local area within Emilia-Romagna Region. Based on this analysis, three main issues emerged. The first issue involves the need for renewed tools and instruments in favor of Teachers/Trainers and NGOs to face a growing and multifaceted ESL and dropping out risk, linked to the effects of the multi-year crisis. The second involves the need for providing at the same time skills valuable for employers and children themselves (e.g. soft skills, ICT and digital skills). The third involves learning by doing and that effective learning could be positively recognized and possibly certified. That single experiences have a widespread diffusion, so that more and more teachers and trainers can appreciate and apply them. Experimentations in the form of design-based workshops may also help showing how to include the new tools into the school curricula, supporting students at risk of disengagement with devoted extra activities.

2. Location-based games

A location-based game (LBG) is defined as a form of play that is designed to be played on a device in motion and changes the game experience based on the location (Lehman, 2012). In recent years, location-based services have become more popular due to advanced mobile devices that make the use of these services very convenient. With the rise of location-based services location-based games will also gain popularity and become more wide spread. Location-based Services (LBSs) are IT services for providing information that has been created, compiled, selected, or filtered taking into consideration the current locations of the users or those of other persons or mobile devices. Many applications for modern smart phones incorporate LBSs to provide location-based information. This information can be used to give location-based recommendations, provide navigation information, track movement, conveniently communicate the current location to friends, etc. However, it can also be used in the area of entertainment and learning, to create a new kind of games that makes the position of the player an essential part of the game.

Video games are, by their very nature, built around interaction and participation. Jenkins (2006) refers to 'play' as a process of exploration and experimentation, and positions games as 'problem sets' which require iterative approaches to forming solutions. Due to their fundamental difference from traditional video games, LBGs and their associated play have the potential to change the way gaming is perceived by encouraging players to experiment with locations and identities outside of the transitional confines of the classroom. LBGs may also be viewed as contemporary experiments in storytelling which mobilise players by offering new immersive experiences. As defined by Thorburn and Jenkins (2006), this form of 'media transition' seeks to exploit the immersive nature of games and web-based environments to draw upon the player's familiarity with narrative and themes from more traditional forms of media (books, film and television). Due to the fuzzy border between a game and the real world, LBGs may provide an opportunity for players to establish more meaningful connections between story and location via interaction and play in the physical world.

2.1 Game patterns relating to LBG

According to Lehmann (2012), combinations of game patters can be used to utilise player location within a location-based game A popular pattern according to Lehmann is the one referred to in his classification as *Search-and-Find*. The basic concept here is that the player has to reach a destination. This destination is always a fixed point in the game world, meaning that the geolocation for this specific destination does not change. This is also the case if no specific geolocation is given, since the player has then to choose from a range of locations which are fixed. The most famous LBG genre using this pattern is geocaching. In this type of games the player has to find an object which is hidden at certain GPS coordinates. This object is usually a real world box containing various items with the aim of the game to locate the box using the GPS coordinates.

A similar game pattern to Search-and-Find is classified by Lehman as *Follow-the- Path*. In this game pattern the player has to reach a destination; however, the focus is not on the destination itself but on the way the player reaches it. It typically involves comparison with a predefined route similar to a suggestion coming from a navigation system. Finally, *Chase-and-Catch*, is another popular pattern for LBGs which requires the player to hunt a moving object in the game world. This object can be another player, making the game very similar to the traditional children's game tag, or a virtual thing only existing within the game world. Usually the player has to reach the object he is chasing or he has to get to know its current location in order to successfully catch it. The basic concept here is that the destination is frequently changing.

2.2 Challenges relating to LBG

According to Lehmann (2012), LBGs have several challenges to development including battery life, storage capacity, processing power and the problem of telling a story in a location-based environment. Papageorgiou and Kolovou (2015) present an overview of these challenges and suggestions for managing them. According to the authors, the very nature of LBGs, being placed in the physical world and using actual locations and places as their backdrop, poses several challenges to both designers and players, such as energy consumption, network coverage or GPS accuracy. Using GPS on a mobile device while being connected to a wireless Internet at the same time results to high-energy consumption in most devices. Shorter game sessions and offline intervals or content introduced through QR codes can reduce the energy demands of an LBG. Poor reception of GPS signal or inaccuracy of positioning systems can cause interferences to the player's experience. A strategy that may efficiently address this problem is to increase the range of the geolocated virtual objects so that a non-accurate location would have fewer possibilities to interfere with the gameplay. Inadequate wireless internet reception and low cellular coverage. is not unusual in natural areas and in some urban areas as well. Testing the signal of different providers on-site with mobile devices before starting the game could prove useful for two reasons: firstly, to define the field of action for the game more precisely; and secondly to choose a provider that offers the best coverage. Portable hotspots can also be utilised for data sharing in such cases.

3. Design process

Design projects like Code RED reply on input from samples of end-learners who are viewed as participants. However, the multidisciplinary nature of these projects mean that input may be gathered from a variety of participants including teachers, classroom assistants, design consultants, managers, technicians and students. An alternative classification for end-users in these projects is to view them as 'design informants' (Bates et al., 2010) with emphasis on facilitation of design activities with participants whilst minimising input from their educators.

3.1 Design workshop overview

Workshop activities applied the shared design facilitation method of 'Adult-initiated, shared decisions' within Hart's Ladder model of participation (Hart, 1992) where activities are initiated by adults but roles and responsibilities are shared with the young people. Adults may have the initial idea but are willing to share the decision making with informants, viewing it as a collaborative interaction. An initial process of 'co-operative enquiry' (Druin, 2002) allowed informants to explore new design ideas using low-tech prototyping tools including pen-and paper drawings. A subsequent process of 'participatory design' allowed participants to build upon these design using digital design tools such as game authoring software and focused, formal workshop discussions. Finally, a post investigation presentation of work by informants to collaborators is used as an opportunity for participants to reflect on the design process and verify the authenticity of the design documentation produced.

A summary of key objectives for undertaking a short term participatory design project with design informants as part of a wider project can be found in **Error! Reference source not found.**. This template of activities was undertaken as weekly meetings (positioned as workshops) between project participants and investigators (functioning as facilitators to the design process). This template has served as a model of good practice which could be modified by facilitators as required to maximise the potential output based on the characteristics and expectations of the local participant group.

Table 1: Key objectives of a short-term participatory design project

#	Objective	Activities
1	Familiarisation	Introduction of digital tools, examples of previous work, set expectations, discuss deliverables
2	Conceptualisation	Process of co-operative enquiry into game concept, brainstorming and low tech prototyping of ideas
3	Creation	Specify design ideas using template, convert ideas into digital resources
4	Modification	Share resources via play-testing, discuss progress, challenge ideas, revise objectives
5	Presentation	Reflect on design process and discuss role, present results to investigators and educators

3.2 Considerations for LBG development

Mobile games may be particularly suited for creating educational experiences in informal settings. Mobile media and augmented reality has a unique ability to unite the advantages of educational video games with place-based learning (Squire et al., 2007). Participants were encouraged to focus on a story, setting and narrative for their products. This resulted in the production of design artefacts including illustrations, storyboards and design descriptions in the form of computer presentations. Participants were encouraged to keep their idea specific and to consider the tools that will be used for the game, where it will be played, the meaning and message they will convey (e.g. overcoming difficulties in school) together with the media (text, photos, audio, video) they would use.

An important outcome from this process included design documentation used to convey and describe the intentions of participants. This output was considered to be living documents, that is, a piece of work which is continuously improved upon throughout the implementation of the project. Emphasis on intergenerational storytelling and core concepts of location-based game-design employed in other projects (Saridaki and Kolovou, 2014). These design documents were intended to be made of text, images, diagrams, concept art, or any applicable media to better illustrate design decisions. According to Gagnon (2012), the steady adoption of activities such as social networking, micro-blogging and video sharing amongst students represent great value in pursuit of better curricular design. Facilitation of such activities was also a consideration of the design team when designing workshop activities.

Careful considerations were also made for selection of a suitable development platform for the LBG output related to the project. ARIS (Augmented Reality and Interactive Storytelling) is an authoring tool as well as an iPhone application that work together to create mobile, locative, narrative-centric, interactive experiences. ARIS has been chosen as a reference tool among other open-source platform because it offers a multimedia basis of demonstration for the principles of location- based game's design. ARIS platform demonstration covers a broad field of complex game design components, such as geolocation data, fictional non-player characters, location sensitive informational objects, interactive dialogues between players and non-player characters, QR code input and multimedia input. At the same time it offers a solid framework of an active on-line community on issues of educational game design which offers valuable information resources for the participants.

4. Workshop output

4.1 UK workshops

In the UK, workshops worked with Junior college students aged 16 and over as part of scheduled school sessions. Workshops started with 3 groups and were deemed to fit-in with normal school life and activities. Participating students were successful in formulating a game concept suitable for LBG transfer surrounding lifestyle choices such as alcohol and drug abuse which may contribute to ESL. Facilitators acknowledged the high quality of artwork which was created as part of this process and sought to preserve the representation of this artwork in the final game. Some of the themes identified by participants as contributing to ESL include death, relationships, drug and alcohol abuse, family issues (such as divorce) and self-harm. Participants focussed their learning material on drawing connections between such issues and available support services which help young adults overcome such barriers.

4.2 Dora's Box

The above project brief was implemented as a location-based game by Greek partners using the ARIS platform. Dora's Box is a location-based game for the Code RED project. It is based on non-textual content and is intended to be accessible for people with intellectual disabilities. The game uses material scoped from the Code RED design workshops in the UK and is designed to complement curriculum content relating the identification and removal of barriers to employment amongst young adults. The game focuses on the presentation of positive and negative factors which are associated with ESL. Positive factors which are presented within the game include recognizing skills and abilities, coping with stress and keeping healthy, personal hygiene, language skills and commitment. Negative factors which the game addresses include the consequences of a loss of self-esteem, understanding anger and aggression, problems relating to stress and advice relating to bullying and abuse. The game is designed in ARIS 1.0 editor for iOS devices using the ARIS app.

The game is inspired by the myth of Pandora and curiosity to learn more about a topic of interest. These themes are adapted as part of the game design to focus on 'good' and 'evil' collectables released from a box (Dora) which are then concealed within identical vessels for collection by the player. The player must approach the location where each of these are stored (within the virtual space) to open them and learn more about their contents. The game is set in physical space while the setting is defined by the player's location. This makes the game playable anywhere and it is not dependent the environmental properties of any particular location or country. The genre of the game is defined as a collection game using speed and strategy to complete the tasks. The player aim is therefore to approach the physical location of virtual objects using a game map interface before they disappear. The player must identify positive themes which these objects represent (and collect them) whilst separating their negatively themed counterpart for disposal.

The game allows items to appear on the map gradually using a predefined algorithm for positioning content using principles relating to Lehman's (2012) Chase-and-Catch game classification. Negative items can be ignored when found and viewed by the player without reappearing on the virtual map. The game is completed when the player has collected and assembled all of the positively themed objects relating to ESL and dropout. After the game has concluded, a player may access an inventory of items for review and reflection. This can be extended into discussions with physical teachers using the visual imagery displayed in the game window. Other learning themes which may be addressed by this game include familiarization with mobile technology, using a map and orientation around a physical space, separation of content based on selection criteria and the ability to make choices in real time. A visual overview of key tasks within the game can be found in Figure 1.

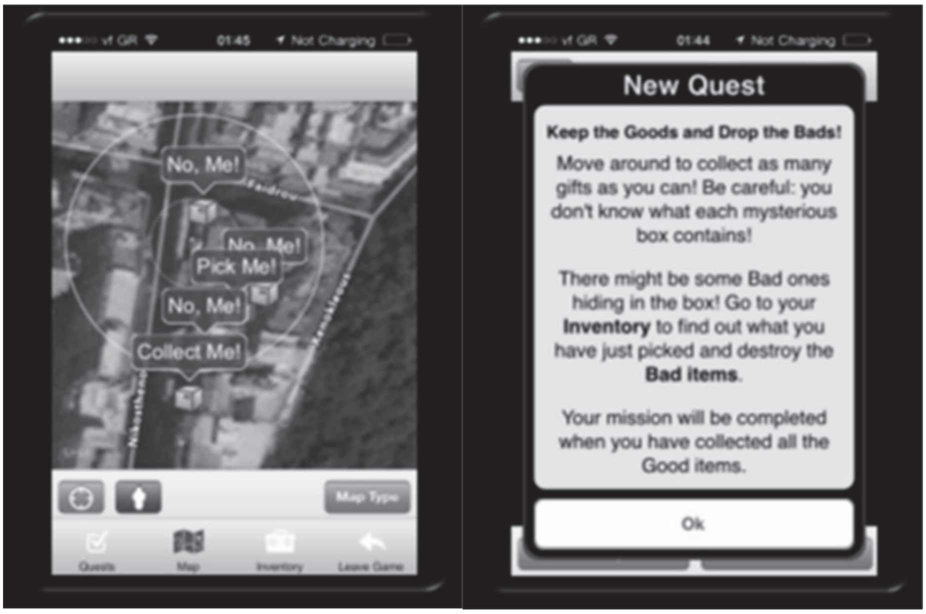

Figure 1: Example of interface design for key tasks within Dora's Box location-based game

4.3 Greek and Italian workshops

Greek game design workshops took place in a welfare, non-profit, non-governmental organization supervised by the Ministry of Labour Social Security and Welfare. This Foundation offers services to children and young people with intellectual disability and other developmental disorders as well as giving support to their families. The participating workshop group was formed by students 14-18 years, teachers and members of the scientific staff of the foundation. Students would design location based games using open web platforms and smartphones. A location-based game (or location-enabled game) is one in which the gameplay somehow evolves and progresses via a player's location. Thus, location-based games almost always support some kind of localization technology. The participating school formed a game design team, they discussed about games and game design.

The ideas for implementation as a final product were combined with output from Italian partners within the Code RED project involving six children (four males and two females) and six adults (the researcher, the digital facilitator, the relational facilitator, two participants from local Job Centres dealing with young adults at risk of become NEET, one participant from VET Centres not directly engaged with children courses and classes). Italian participants were successful in designing an orienteering-based LBG to promote cultural heritage via exploration of local landmark in the form of an ancient castle. Participants selected a game based on a journey in stages to get the exit through the reconstruction of a map of a local landmark. The idea enabled players to assemble pieces of a map and information relating to the different environments in which the character interacts whilst being directed by a non-playable character within a fictional setting.

4.4 Eve's World

The key themes from this concept were mapped into a design document by project investigators to create an LBG to target educational de-motivation and dropout from IVET. This process was guided by workshop output and game design principles relating to the 'Hero's Journey' as described by Campbell (1949). Other considerations were made for embedding exploration, humour, popular cultural references, text, video, emoticons all to draw a connection with real life situations.

The player is asked to participate in an adventure role playing game as the main character of the game. The setting is a game-design workshop which the player decides to skip due to lack of interest. The character's mobile phone is used as a 'gimmick' in this scenario for communicating with a fictional virtual character belonging to an old fictional videogame. The virtual character (Eve) asks the player to create a new game world for her to live in. In order to achieve that the player is introduced to the basic notions of the CODE Red Curriculum such as building language skills, taking responsibilities managing tasks while being introduced to the game design platform of ARIS. During the game the player meets more virtual characters which add to the plot such as classmates, a group of older children bullying one of the player's companions, and the workshop facilitator. The player is rewarded throughout the game by collecting points of leadership, charisma, commitment and self-esteem for achieving each task asked by the game, while losing boredom points that initially made the player to abandon the classroom.

The learning value of the game focuses in the positive turnout of the everyday decision-making routine of a teenager who lacks interest in school. The players are introduced to the value of developing their skills in an engaging playful context. Moreover, an introduction to the basics of LBG design is made using the interactive content of the LBG as guidelines. A visual overview of key tasks within the game can be found in Figure 2.

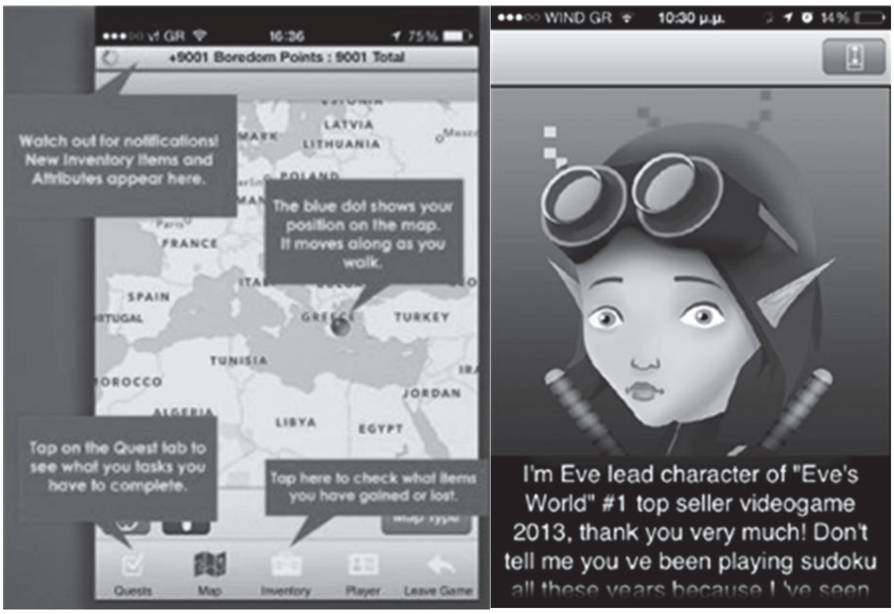

Figure 2: Example of interface design for key tasks within Eve's World location-based game

5. Closing comments

The Code RED project has successfully made use of the ARIS platform to implement location-based-gaming solutions which attempt to tackle the issues contributing to ESL within the EU. These products have been co-designed with target users who were able to reflect upon the importance of education and its relevance to them as young adults as part of the associated design activities. This result will inform future project output which seeks to extend existing employability curriculums to enable teachers and trainers to deliver co-design activities in the form of an open standards and accessible e-Learning environment.

The LBG output from the Code RED is scheduled to be piloted with end-users in 2015 to assess the effectiveness of these tools in addressing dropout from IVET and ESL in the EU. These 'proof-of-concept' materials may also be used to address factors contributing to ESL in the EU (in particular low self-esteem) by valuing all contributions made by young adults via the collaborative construction of new educational materials.

Acknowledgements

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Non-Invasive Assessment of Motivation in a Digital Educational Game

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Abstract: Digital educational games (DEGs) have the potential to provide an intrinsically motivating learning context. With adaptive mechanisms that react to the learner´s current motivational state this potential can be further exploited. A learner model, based on continuous and valid assessment of a learner's motivational state is required. However, it would impair the flow-experience (Csikszentmihalyi, 1990) if a learner is repeatedly asked to evaluate his or her current motivational state, e.g. by a questionnaire that occurs in short time intervals on the screen. Hence, it is necessary to apply an approach that assesses the motivational state in an ongoing, implicit and non-invasive way. We suggest a non-invasive assessment procedure that is based on the observation and interpretation of so-called behavioural indicators (BIs), i.e. learner´s actions and interactions with the virtual environment that are gathered as log-data. A substantial set of behavioural indicators has been elaborated, such as mouse-click rate, whereby some of them are derived from information foraging theory (Pirolli and Card, 1999). For example, the relative amount of time the learner is exploring the virtual environment can be considered as between-patch processing while the relative amount of time the learner is communicating with other game characters can be considered as within-patch processing. Values for each behavioural indicator (e.g. amount, frequency, seconds, etc.) are gathered repeatedly after predefined time slices, lasting for 40 seconds. The paper describes the results of an empirical investigation to examine the predictive validity of the BIs. Participants played a DEG while being asked to answer items of a short form of the Questionnaire of Current Motivation (QCM; Rheinberg, Vollmeyer and Burns, 2001). The QCM has been developed to measure current motivation in learning situations with respect to four factors: anxiety (of failure), probability of success, interest and challenge. Multiple linear regression models with the BIs as predictor variables and the QCM´s scales as criteria allowed for predicting probability of success, interest and challenge. There was no valid BI for the fourth scale of the QCM, anxiety. We conclude that our approach, being a valid non-invasive assessment procedure suits well to fairly evaluate the effectiveness of on-line game adaptations that aim to enhance the learner`s motivational state.

Keywords: game-based learning, motivation, non-invasive assessment, behavioural indicators, predictive validity

1. Background

In general, digital educational games (DEGs) provide an appealing learning context which is intrinsically motivating for learners. However, in many cases, this great advantage of DEGs is often taken for granted and there are only a few evaluation studies which explicitly examine this hypothesis by means of questionnaires, interviews or behavioural observations. Even if evaluation results indicate that a particular DEG is intrinsically motivating, a game which adapts to the learner´s current motivational state, e.g. by adjusting its difficulty level, could fully exploit this great potential of a motivating and appealing learning context. Depending on the learners performance it might be useful to adapt the difficulty level between two consecutive game sessions: if the performance was very high, the difficulty level should be increased; if the performance was rather low, the difficulty level should be decreased. A medium difficulty level provided by the game should ensure an accurate level of challenge for the learner. An accurate level of challenge is known to be the optimal condition for the occurrence of flow (Csikszentmihalyi, 1990).

In some game genres, such as role or adventure games, the duration of a single game scenario may last from several minutes up to hours. In these cases an ongoing assessment of the motivational states for in-game adaptations would be required, even though it certainly impairs a learner´s flow-experience if he or she is repeatedly asked to evaluate his or her current motivational state; e.g. by means of a questionnaire that appears in short time intervals on the screen. Hence, it is necessary to assess the motivational state in an implicit and non-invasive way.

The non-invasive assessment procedure which is at the focus of the present paper is based on the automated interpretation of the learner`s actions while being engaged with the game (Kickmeier-Rust and Albert, 2010, Schönbrodt and Asendorpf, 2011). The learner´s actions - in our case these actions and interactions are called *behavioural indicators* - are gathered as log files.

1.1 The TARGET game

In the context of the TARGET project (7th Framework programme; http://www.reachyourtarget.org) a substantial set of *behavioural indicators* (BIs) has been elaborated and defined (see Table 1).

A majority of the BIs are suited to the game mechanics and the context of the TARGET game: In this game, the learner is represented by an avatar and interacts with several agents, so called non-playable characters (NPCs). As an example, the game scenario called "Stakeholder Management" consists of an office and various outdoor locations. The learner has to communicate with different NPCs and to collect relevant pieces of information for mastering the scenario (see Figure 1). To this end, the learner has the opportunity to use several tools, as for example a chat tool to communicate and to negotiate with the NPCs, a teleport tool to switch between different locations and a "face cam" which shows the own avatar`s face. This allows the learner to evaluate and self-reflect on whether or not the emotions are expressed as intended by the learner. With the chat tool the learner may enter text freely, while the NPCs answers were designed to respond to topics addressed by the text.

Figure 1: A screenshot of the TARGET game´s virtual environment and chat tool

1.2 Behavioural indicators

Table 1 summarizes the whole set of BIs which were developed for the TARGET game. For a detailed description of the BIs and their operationalization see Bedek et al (2011, 2012).

The whole duration of a game-play is split into time-slices (lasting for 20, 30 or 40 seconds) and thus, the BIs "raw values" (i.e. seconds, absolute numbers, etc.) have to be considered as values *per time slice*.

Table 1: Set of Behavioural Indicators and their operationalization

#	Behavioural Indicator	Operationalization and Explanation
1	Click rate (*cr*)	The amount of mouse clicks per time slice
2	Mouse movements (d_{MM})	The Euclidian distance between the mouse pointer´s position *t* and $t + \Delta t$ is calculated. The sum of all Euclidian distances per time slice is d_{MM}.
3	Distance of "view" - movements (d_{VM})	The amount of vertical and horizontal "head movements" of the learner´s avatar; counted in units of visual angle changes. Considered as an indicator for search behaviour in the virtual environment.

#	Behavioural Indicator	Operationalization and Explanation
4	Relative exploitation of available tools (p_t)	Number of actually used tools (e.g. face cam) divided by the total number of available tools.
5	Frequency of tool-usage ((f_t)	$ft = \frac{fT_1 + \ldots + fT_n}{n} \cdot \frac{T_W}{Tts}$ Indicator for the average usage frequency of tools T_i. (T_w / T_{ts}) acts as a weight so that the indicator takes on a high value only if the learner made use of the tools to gain information through an exhaustive conversation. (T_W is the time spend on Within-patch processing, see BI # 11; T_{ts} is the duration of the time slice)
6	Frequency of communication tool-usage (f_{ct})	Number of chat tool usage
7	Frequency of interactions with NPCs (f_i)	Number of lines entered in the chat tool
8	Frequency of expressing positive emotions	Number of function key presses representing positive emotions (e.g. the key F3 leads to the expression of “Joy”)
9	Frequency of expressing negative emotions	Number of function key presses representing negative emotions (e.g. the key F6 leads to the expression of “Anger”)
10	Inactivity (T_{ia})	Units of time the learner doesn`t press any keys and doesn`t move the mouse (see below)
11	Within-patch processing (T_W)	Units of time spent on communicating with NPCs (see below)
12	Between-patch Processing (T_B)	Units of time spent for exploring the *environment* (see below)
13	Extent of NPC-interactions weighted by Within-Patch processing (I_{NPC})	$I_{NPC} = nNPC \cdot \frac{T_w}{T_{ts}}$ Number of NPCs contacted by the learner, multiplied by weight (T_w / T_{ts}) (T_W is the time spend on Within-patch processing, see BI # 11; T_{ts} is the duration of the time slice). The indicator takes on a high value if NPC-interactions are accompanied by an exhaustive conversation.
14	Information gained (G)	$G = \lambda * T_B * g$ (see equation 1, below)
15	Rate of Information Gain (R)	$R = G / (T_B + T_W)$ (see equation 3, below)
16	Profitability (π)	$\pi = g / t_W$ (see equation 4, below)

A subset of BIs (#11-#16) was derived from the *Information Foraging Theory* (IFT) as described by Pirolli and Card (1999). The IFT describes the strategies that people apply to seek, gather and consume information from external sources. External sources are called patches, for example communication partners or on-line documents. In order to gather relevant pieces of information, the available time has to be divided into the search for new - so far uninspected - patches (e.g. journal papers) which might encompass valuable pieces of information, as well as time which needs to be spent to “consume” this patches (i.e. to extract relevant information). The time spent on exploring the environment for new patches is called *Between-Patch processing* T_B (see BI #12). The time spent on consuming a single patch is called *Within-Patch processing* (see BI #11). In the context of the TARGET game the only patches which supposedly have valuable information are the NPCs. Thus, time spent on communicating with an NPC is defined as *Within-Patch processing* T_W. The remaining time, i.e. the time which is neither spent on searching for new NPCs nor for communicating with a particular NPC, is defined as *Inactivity* T_{ia} (see BI #10).

In addition to T_B and T_W, other variables based on the IFT from Pirolli & Card (1999) have been applied as BIs: For example, G (see BI #14), which represent the total amount of information gained is given by the following equation (1),

$$G = \lambda * T_B * g \quad (1)$$

where λ is the prevalence, the average rate of encountering patches (i.e. NPCs) and g is the average gain per patch. The prevalence λ is given by equation (2),

$$\lambda = 1 / t_b \quad (2)$$

where t_b represents the average time in seconds between processing patches. Finally, g represents the average gain per patch (i.e. during the conversation with an NPC), which is the number of relevant propositions extracted during the conversation.

The rate of valuable information gained per time-slice, R (see BI #15) can be obtained by equation (3).

$$R = G / (T_B + T_W) \quad (3)$$

The more (or the faster) relevant information is extracted during the conversations with NPCs, the higher the value of R.

Finally, the so called Profitability π can be computed by equation (4),

$$\pi = g / t_W \quad (4)$$

where t_W is the average time in seconds spent on within-patch processing and is computed by dividing T_W by the number of phases in which *Within-Patch processing* took place. Hence π represents the amount of valuable information she or he actually extracts from conversations, taking into account the amount of time needed for this process.

1.3 Aim and hypotheses

The aim of this study is to examine whether the learner's behaviour during the game play (measured by BIs) can predict her or his motivational state as measured by items of the *Questionnaire of Current Motivation* (Rheinberg, Vollmeyer and Burns, 2001; see section 2.2, Material) . In particular, it is assumed that indicators reflecting this allocation of time among *Between*- and *Within-Patch processing* can help to make inferences about motivational aspects of a learner's state during his or her game-play. The rationale underlying this assumption is that motivated learners try to extract as much valuable information as possible and this can be only ensured when spending time on both, *Between*- and *Within-Patch processing,* respectively.

2. Method

2.1 Participants

The sample size was 32. Half of the participants were male, the other half was female. The overall sample ranged in age from 18 to 42 years (M = 26.3, SD = 4.7). All participants recruited for this study were German-speaking and part of an opportunity sample. The participants received 15 Euros for participating in the study.

2.2 Material

In this evaluation study we used a short form of the *Questionnaire of Current Motivation* (QCM; Rheinberg, Vollmeyer and Burns, 2001) to measure the participants' explicit achievement motivation. The QCM has been developed to measure current motivation in learning situations with respect to four scales: *anxiety*, *probability of success*, *interest* and *challenge*. The *anxiety*-scale contains items that address the negative incentive of failure. *Probability of success* refers to the participant's certainty to succeed. Items on *interest* ask for the degree to which the participant appreciates the task. Finally, the scale on *challenge*, measures if the current activity is interpreted as an achievement-related task. For each of the four factors we selected those two items with the highest item-scale correlation (Freund, Kuhn and Holling, 2011). The original items (in German), are listed in Table 2. In addition to that, English translations are provided in parenthesis below of the German items (Pedroni, 2006). It has to be noted that the translations from Pedroni (2006) have a slightly different focus: While the original QCM focuses on a single task ("Aufgabe"), the version from Pedroni (2006) is focusing on projects (as a set of tasks). For a word-for-word translation it would be necessary to substitute "project" and "project assignment" with "task".

Table 2: Items selected from the QCM to measure interest, challenge, probability of success and anxiety

Factor	Items
Anxiety	Ich fühle mich unter Druck, bei der Aufgabe gut abschneiden zu müssen. (I feel pressure having to perform well solving the project assignment.)

Factor	Items
	Ich fürchte mich ein wenig davor, dass ich mich hier blamieren könnte. (I'm a bit afraid of being embarrassed by my performance in the project.)
Probability of Success	Ich glaube, der Schwierigkeit dieser Aufgabe gewachsen zu sein. (I think I can tackle the difficulties of the tasks involved in the project assignment.)
	Ich glaube, ich schaffe diese Aufgabe nicht. (Probably, I will fail solving the project assignment.)
Interest	Bei Aufgaben wie diesen brauche ich keine Belohnung, sie machen mir auch so viel Spaß. (I enjoy doing the project, I would not need any gratification.)
	Eine solche Aufgabe würde ich auch in der Freizeit bearbeiten. (I would also work on a project like that in my free time.)
Challenge	Die Aufgabe ist eine richtige Herausforderung für mich. (This project assignment is a real challenge for me.)
	Ich bin sehr gespannt darauf, wie gut ich hier abschneiden werde. (I am very curious how well I will do in this project.)

2.3 Procedure

The participants received a short tutorial to ensure that participants became familiar with the aims of the study, the game scenario and the navigation through the virtual environment. For the game-play, we selected the scenario called “Stakeholder Management” briefly outlined above. The participant was asked to slip into the role of her or his avatar Ingrid representing manager of a renewable energy company. The storyline was as follows: Currently, Ingrid’s company is planning to build a new windmill park located on the Southern coast of Norway. Ingrid’s, i.e. the participant’s task is to engage in dialogues with two citizens of the town where the windmill park should be built. The two citizens are the mayor of the town and the farmer Jens. The goal is to convince both citizens of the intended project by applying a clever negotiation strategy. Furthermore, the participants got the hint that particular topics, such as “Environment”, “Community and Reputation” and “Economy and Conjuncture”, should be addressed in order to have successful dialogues. During the game-play the evaluation tool intermittently popped up. As indicated in Figure 2, the evaluation tool was a frame appearing in the centre of the computer screen and presenting one item together with a 9-point rating scale. At the same time, the background of the game was greyed out.

Figure 2: The evaluation tool appeared intermittently on the screen

Both items of a particular scale were presented in a block. Once the participant rated the item and clicked on the NEXT-button, the remaining item of the scale appeared. Another click on the NEXT-button enabled to continue with the game-play. The time intervals between the blocks were 3 minutes on average (SD=0.5 minutes). The scale to be presented in a block was chosen randomly (without replacement) as well as the sequel of the items within a block. After all four scales have been presented, the selection of scales started again. Thus, each of the four scales of the QCM has been presented at least two times. Once this was the case, the participant was informed that he or she could either stop or continue with the game. Overall, the game-play lasted for 25.3 minutes on average (SD=2.5 minutes).

3. Results

The purpose of the statistical analysis was to answer the question whether the learner's behaviour during the game play (measured by BIs) can predict her or his motivational state (measured by self-report). We decided to apply multiple linear regression analyses to quantify and evaluate these relations. The BI´s raw values within a time slices of 20, 30, and 40 seconds, just before the occurrence of the evaluation tool, served as predictors and the scale-values of the QCM served as criteria. Table 3 summarizes the results for the stepwise regression analysis for the 40 seconds time interval which delivered better results than the 20 and 30 second slices. In addition to the values *R* and R^2 (explained variance) for each criterion, standardized β-coefficients which help to interpret a predictor's influence on the *R*-parameters are presented.

Table 3: Regression analysis results of the BIs on Motivation

Criterion	p	R	R^2	Predictors	β	P
Anxiety	n.s.	-	-	-	-	-
Probability of Success	0.00*	0.41	0.17	Constant	9.10	
				Between-patch Processing	-0.44	0.00*
				Within-patch Processing	-0.25	0.03
Interest	0.00*	0.33	0.11	Constant	4.54	
				Length of mouse movements	0.33	0.00*
Challenge	0.01	0.35	0.12	Constant	4.48	
				Click rate	-0.41	0.00*
				Length of mouse movements	-0.29	0.02

Note. *indicates that p<.001

There was no BI which contributed significantly to the prediction of *anxiety*. The model identified for *probability of success* was highly significant (*R*=0.41, *p*<.001) and the amount of variance explained was 17% (R^2=0.17). The predictors included in the regression model are *Between-Patch-Processing* (*β*=-0.44, *p*<.001) and *Within-Patch-Processing* (*β*=-0.25, *p*<.05), whereas the former one appears to be a better predictor than the later one. Around 11% of the *Interest* variance (*R*=0.33, *p*<.001) could be predicted by the BI *Length of mouse movements* (*β*=0.33, *p*<.001). Similarly, a proportion of 11% of variance could be predicted for the factor *Challenge* (*R*=0.35, *p*<.05). In contrast to *Interest*, the model for *Challenge* also includes the BI *Click rate* (*β*=-0.41, *p*<.001) besides *Length of mouse movements* (*β*=-.29, *p*<.05).

4. Discussion

With regards to *Probability of Success*, the negative signs of both predictor´s β-coefficients indicate that the less time spent on explorative (*Between-Patch-Processing)* and exploitative (*Within-Patch-Processing*) search behaviour, the lower the experienced *Probability of Success*. It seems that learners who think that they won´t be successful are reducing their effort to search for new patches (NPCs) and to exploit the patches (communicating with the NPCs). Explorative and exploitative search behaviour is considered as crucial for mastering the game scenario since relevant pieces of information need to be gathered to convince farmer Jens (NPC) to sell his land. In other words, learners who are not convinced that they will be successful are not applying according strategies to succeed.

A similar pattern applies for *Challenge*: Both predictors, *Click rate* and *Length of mouse movements,* are negatively related with the criterion, as indicated by the negative signs of their β-coefficients: The lower the number of clicks and the smaller the length of mouse movements, the higher the learners experienced *Challenge*. These results indicate that learners who feel unchallenged increase activities in the game which are not cognitively demanding. Learners who feel challenged or even overwhelmed are reducing these "basal" game activities.

Mouse movements in the game enabled to look around, i.e. to explore the virtual environment, and to turn around the avatar´s head and body. The higher the *Length of the mouse movements* the higher is the learner´s *Interest.* Thus, it can be argued that interest in *playing the game* (rather than interest in succeeding the game) is indicated by a higher amount of explorative (visual search) behaviour.

Overall the results indicate that factor *Probability of Success* is predicted by BIs related to IFT, and the factors *Interest* and *Challenge* are related to “basal” BIs such as *Click rate* and *Length of mouse movements*. Unfortunately, none of the BIs allows for predicting the learner´s *anxiety*. The means and standard deviations of this scale revealed that the variance of the learner´s anxiety as well as their general level of anxiety was rather low. Low variance of at least one variable decreases probability of a correlation between two variables being significant. A slightly different instruction which triggers achievement-related motives is considered for future studies.

5. Conclusion and future research

This paper deals with an ongoing and non-invasive procedure to assess a learner´s current motivational state when playing a DEG. The assessment procedure is based on a continuous gathering of behavioural indicators which serve as predictors in multiple regression equations. The theory of information foraging has been applied as an initial framework which allowed defining some of these behavioural indicators (BIs).

We consider our approach of applying simple metrics derived from a learner’s game interactions (BIs) to infer her or his motivational state as a promising starting point. However, it has to be mentioned that only one out of four of the suggested BIs in Table 1 contributed significantly to the regression models and only three out of four criterions could be predicted by the BIs. In a future study we plan to repeat the same experiment but with emotional factors as criterions. Based on the approach of Peter and Herbon (2006), we will represent the learner’s emotional states in a two-dimensional space of valence and arousal as assessed by the Self-Assessment Manikins (Bradley and Lang, 1994).

With respect to the BIs based on IFT, we have examined whether the general constructs, such as Between- and Within-Patch Processing, can be utilized to characterize a learner’s allocation of attention and search behaviour in a virtual learning environment. Since this endeavour has been successful we can take a further step deepening the application of the IFT. Similar to Pirolli and Fu (2003) who have combined IFT and the *Adaptive Control of Thought-Rational* model (ACT-R; Anderson et al., 2004) to describe searching processes on the Web, it is planned to integrate components of ACT-R to model the information scent of objects (e.g. NPCs) within the learning environment and to predict a learner’s search decisions. Referring to the basal BIs, up to now we have made use of a small subset of possible indicators (e.g. click rate or mouse movements) and a few alternatives that could be tested and elaborated. One promising alternative could be the application of the *Linguistic Inquiry and Word Count* (LIWC), a tool to automatically analyse the emotional connotation (e.g. valence) of written words. LIWC appears to be an effective means to infer a learner’s affective state from her or his chat protocol.

The final aim of a valid non-invasive assessment procedure is to provide in-game interventions, also called micro-adaptations by Kickmeier-Rust and Albert (2010), to increase a learner´s state whenever necessary. In this context this means that whenever the learner´s current motivational state is considered as (too) low, motivating in-game interventions should be provided. Besides the obvious advantage of a non-invasive assessment procedure on its own, there is the additional benefit that the effect of such in-game interventions can be evaluated in a fair manner. An explicit, invasive assessment (e.g. by questionnaires) might disturb the learners´ flow, and in consequence, it might extinguish the potentially positive effect of an in-game intervention. In the course of the TARGET project, several in-game interventions have been elaborated and implemented (Kopeinik et al., 2011). Future research will apply the three multiple regression equations described in section 3 above for evaluating the foreseen in-game adaptations with respect to the constructs Probability of success, Interest and Challenge.

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Learning AI Techniques Through Bot Programming for a Turn-Based Strategy Game

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Abstract: Video games have become an integral part of the educational process. Born and raised in the digital era, Russian students of the 21st century are seduced by entertainment and in contrast they perceive STEM educational activities as boring and annoying. To spark an interest in Artificial Intelligence (AI) programming we decided to implement a competitive contest in the educational process. By combining the developments of the eScience Research Institute and educational techniques, we have introduced elements of entertainment to a group project of 6 ECTS during the second semester of the Double Degree Master's Program in Computational Science. The main goal of this project is to teach students basics of AI programming by creating bots for a strategy video game. Typical tasks and multi-domain specificity stimulate students to discover and apply new information from available sources promoting the principles of self-education and lifelong learning. An exaggerated and concentrated example of diverse behavioral patterns in the game should help students to transfer the patterns acquired from the games to solve real-life problems.

Keywords: artificial intelligence, competitive programming, turn-based strategy, gamedev, game development

1. Introduction

Technology is becoming increasingly predominant in modern world. The minimum amount of knowledge that needs to be learned is expanding as well. Traditional strategies of teaching cannot stimulate students to study huge amounts of material. Thus it is high time to add new methods and techniques into educational processes. Learning process based on games is well-known for a long time, though it is more connected with earlier stages of a person's development. The crucial part in implementation of game-based approaches in other stages of education was played by technology improvement, digital games in particular (Moreno-Ger et al. 2009). In the first decade of XXI century there was a substantial rise in amount of researches in this scientific area as well as expansion of researchers' locations (Hwang & Wu 2012). Games are commonly used in all areas of education from liberal arts to STEM learning, and are utilized in various ways. In primary education and liberal arts students learn through playing educational games (Rankin et al. 2006), while other approaches are often used for professional education in STEM fields (Becker 2001). There are a huge variety of ways for using games in STEM learning: games are applied as design patterns for application design (Gestwicki 2007), primitive games are used for learning of programming basics (Rajaravivarma 2005) as well as for advanced AI courses as an environment for competitive programming (Wallace et al. 2007).

Chang and Chou (2008) propose approach of smooth involvement in process of programming language learning. Students spend more time on playing games instead of starting to program from the very beginning. This approach is undoubtedly useful for early stages of education and was successfully used in an introductory course of programming. Chiang (2007) applied games in an advanced course of machine learning and AI. It is assumed that students have a high level of knowledge and they know how to code. During the course students are preparing a playable AI for a full value game, consequently in this case more interesting and enthralling results can be observed during and after the study project.

Besides using games as elements of separate courses more general approaches recently became fairly common – entire courses on video game development became available for STEM specialists. Cagiltay (2007) suggests using game development courses as complementary to the main software development project. They demonstrate that students who completed the additional course turned out to be more successful at completing the final project compared to those students who did not take the course. Kuhl et al. (2014) describe their experience of implementing an even more extensive approach to game development learning: they created full-cycle gamedev team projects which involved full multidisciplinary teams of students from elected project managers to programmers, artists and sound designers, all of which could participate in the project.

Great variety of research works on game-based STEM learning and the conclusions made in those works confirm that this approach is successful and promising. In this paper we present our approach to integrating game-based learning into Master's Program in Computational Science.

The rest of the paper is organized as follows: Section 2 presents presuppositions, related work analysis and motivation for our work. Section 3 describes proposed game environment and explains software API. Section 4 presents tournament event and its results. Section 5 describes some discussion issues and future work. Finally, the conclusions are presented in Section 6.

2. Presuppositions and motivation

Born and raised in the digital era, Russian students of the 21st century are seduced by entertainment and in contrast they perceive STEM educational activities as boring and annoying. To spark an interest in AI programming we decided to implement a competitive contest in the educational process.

After studying background in the field of competitive programming in education we can choose several works which we used as base during our research. Lawrence (2003) applied a competitive game for learning the basics of programming. The development of the game started quite some time ago in C++ programming language. In their work there is good centralization and automation of the event by using a web-site and a system of automatic battles. In addition there are a number of bots written by the teachers which students try to defeat besides their classmates' AIs. Mechanics of the game is rather simple and does not require any specific knowledge in tactics for AI programming which can be considered as an advantage and disadvantage at the same time. It allowed students without strong background to participate in the event, but on the other hand it makes the problem a lot easier for students who have high level of knowledge. It should be noticed that this application does not have any interesting graphical user interface which declines keenness and excitement during the competition between two AIs.

Kim's article (2006) established another impressive approach in the area of competitive programming. They developed the separate client for a popular commercial game Unreal Tournament, which was able to connect to a game server and implement students' bots into the game. As a result they organized an enthralling tournament between AIs which were created by their own students. All students and teachers were pleased by results, however the tournament like this requires a lot of time to prepare. Complete commercial solution demands huge efforts to develop additional modules, furthermore during the tournament these modules had to be modified. Another drawback was that the students were bounded by individual marks for this course which excluded emergence of team strategies of any kind.

Another work (Milone et al. 2009) which was close to our ideas describes long-term experience of competitive project among the students. There was a competition between AI of colonies of microorganisms which had to fight against each other to survive in a Petri dish. In contrast to aforementioned works where competitive element is the part of the course Milone and his colleagues used informal learning methodology, which provided students an interesting opportunity to exercise the use of their imagination to solve previously unknown problems through self-learning, without a formal obligation, which also promotes self management.

By combining the developments of the eScience Research Institute and the educational techniques described above, we have introduced the elements of entertainment to a group project of 6 ECTS during the second semester of the Double Degree Master's Program in Computational Science. Finally teachers and students of senior year teamed up to develop a game environment named "Submarine Wars".

3. Submarine Wars

"Submarine Wars" is a video game-like environment designed for competition between two AIs which control the team of submarines. The application was developed in the Fusion Framework, a framework for rapid prototyping of interactive applications, which was created in the eScience Research Institute. The application is written mainly in C# programming language.

3.1 Game rules

"Submarine Wars" takes place in the sea where two enemy fleets of submarines encounter each other. The game is played on a hexagonal grid. We choose 64x32 board size with "odd-right" pointy top cell alignment. One team starts the game at the bottom left corner, another one starts at the top right corner. Each cell can be one of three types: deep water (good sound propagation, no naval mines), shallow water (low sound propagation, possible enemy's naval mines), or dry land (impassable for submarines, casts acoustic shadows). Each submarine is armed with naval mines (which could be planted in shallow water) and homing torpedoes (attack range is about 12 cells, and homing range is two cells). The main goal is to eliminate enemy submarines.

To get natural and playable map we decided to generate the game field randomly using Perlin noise algorithm (Perlin 1985). See figure 1.

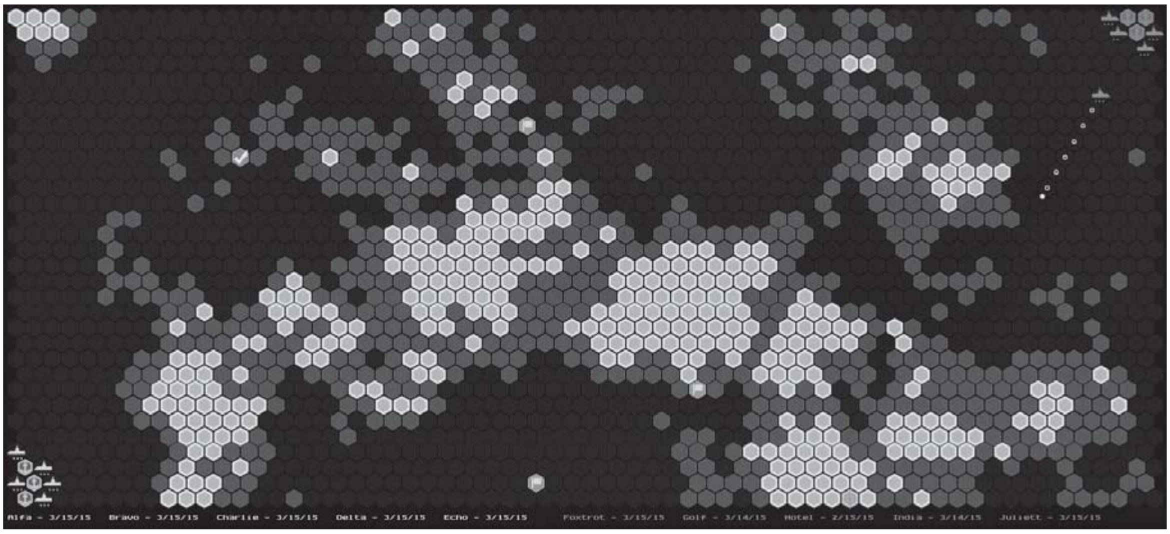

Figure 1: General game view. Light cells is the land, medium gray cells is shallow water and dark gray cells is deep water

Initially, teams consist of 5 submarines where each submarine has 25 torpedoes, 25 mines and 3 points of hull integrity (e.g. "health"). Torpedo hits, naval mines or collisions with other submarines decrease hull integrity by one. When hull integrity reaches zero the submarine sinks.

On each turn a randomly selected submarine can move on one, two or three cells, launch a torpedo or place a naval mine. To place a naval mine the submarine has to leave the occupied cell. The faster the submarine moves the more noise it produces. If the submarine tries to move onto a cell occupied by another submarine both of them will be damaged and the first one will be moved back to the previously traversed cell.

Torpedo movements are similar to that of submarines but they can travel much longer distances. Torpedoes explode when they hit a submarine or upon reaching the travel distance limit. This means that torpedoes cannot survive for multiple turns as they always explode at the end of the turn. If a torpedo finds itself within the range of one cell from any submarine, including the friendly ones, it directs itself at the submarine.

While many such games provide detailed information about the game state (enemy positions, health, environment configuration, etc.), our approach assumes there is a lack of information about the game situation and the enemies available to competitors. Each submarine has access to information about the game field configuration, coordinates of the allies, hull integrity and weaponry. However, no information about enemies is available. Only the noise that propagates through the water informs bots about game events, like enemy movements, positions, explosions, and torpedo hits.

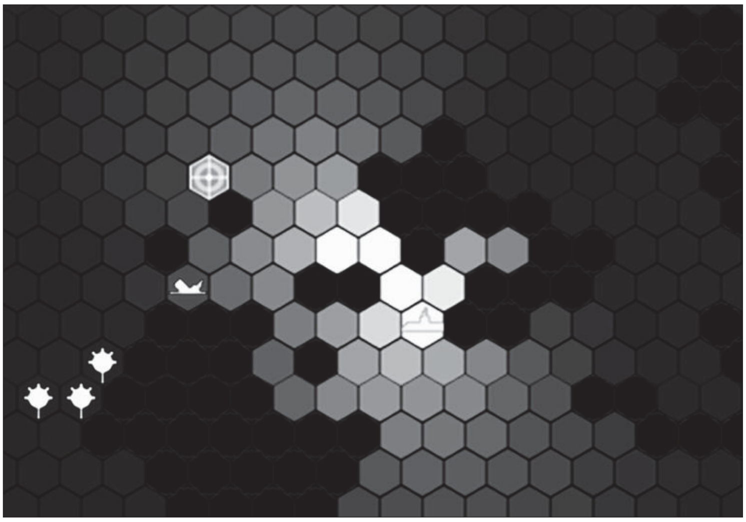

Figure 2: Sound propagation (brighter cells mean more noise level)

Noise propagation is simulated by solving the heat equation for limited time, where sound sources are treated as constant sources of heat. Land is treated as holes, shallow water has low thermal/sound conductivity and deep water has high thermal/sound conductivity (Figure 2). Such approach produces soft acoustic shadows and a good differential approximation of heat/sound source direction.

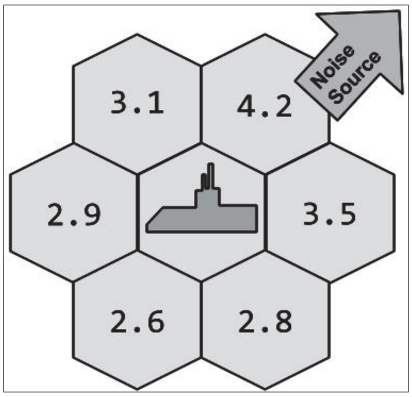

Figure 3: Noise information received by submarine.

After each turn submarines receive information about all events that produce noise as noise intensity in each adjacent cell (Figure 3). The main challenge for students was to make AI able to predict opponent's behaviour under conditions of severe information shortage.

The fact that submarines are selected randomly each time is the one of our game's main features. It means that participants of the tournament could not predict when will be their next move and which submarine exactly will take it. That is how the problem of creating Artificial Intelligence for "Submarines Wars" became even more interesting: students wanted to find not only optimal strategy against the opponents but they also wished to create a plan which will be successful in any possible case.

3.2 API

Application Programming Interface (API) was designed to remove the need to develop basic functions of artificial intelligence, such as pathfinding, game event notifications and noise detection. All the low level routines are provided by the API, which allows students to pay more attention to developing good strategies and heuristics for their AI.

Bot actions are represented as objects of the following classes:

- Movement. Submarines can move freely to any cell on the game field except dry land. The path length is limited to 3 cells per turn. Moving to an adjacent cell produces the least amount of noise, while movement across 3 cells produces the most noise.

- Launch torpedo. To launch a torpedo one must construct a path for it to follow. Torpedo travel distance is limited to 12 cells.
- Plant mine. The mine is planted into the cell currently occupied by the submarine. After that the submarine have to move one step ahead.

Artificial intelligence is inherited from base AI class and consists of following methods which have to be redefined:

- *void DetectNoise(List<Tuple<Submarine, List<Tuple<Cell, double>>>> noise)*. After each move team gets list of noise intensities, which submarines were able to detect. Only submarines which didn't make any noise on the map by themselves can detect some noise.
- *void NotifyTorpedoDamage(Submarine sub)*. If some of your submarines were damaged by a torpedo, this method will be called with damaged submarine as parameter.
- *void NotifyMineDamage(Submarine sub)*. This method is called if your submarine was blown up by a mine.
- *void NotifyAccident(Submarine sub)*. This method is called if a submarine from your team collided with another submarine.
- *AIAction NextAction(Submarine sub, GameField field)*. If now it's your turn to move then this method will be called with the submarine which has to make a move and game field as parameters. This method should return one of the possible actions: *Move*, *PlaceMine* or *LaunchTorpedo*.

For AI debugging there is a possibility to place markers on the game field. Markers have no influence on the game process and simply allow you to visualize some points marked by AI. There are 5 types of markers: Target, Dot, Check, Flag, Cross. Adding markers to the field is made by calling the method addMarker(Marker), where the parameter is one of the five aforementioned markers. Also it is possible for students to add their own types of markers to the game.

4. Tournament

The tournament took place in February and March, 2015 and consisted of several stages: organizational meeting, 4 stages (3 intermediate stages and final) of battles and the grand finale. This interval gave students time to improve their bots, study competitors' bots and prepare to the next stage. On the organizational meeting the rules of the tournament were explained, the introductory test for all students was held and teams of students were formed. Participants received instructions on how to use "Submarine Wars"' API and got the random AI as their very first opponent for testing and debugging. Using all that students should code a simple AI during the first two weeks of the tournament. Then battles passed every week and after each stage there was a quick discussion and summarizing of the results. After the grand finale students talked about their principles and tactics, the history of their AI development, the problems they faced, and discussed their results. The winners were rewarded.

4.1 Tournament rules

At each stage every team played with every other team on the same map. For each battle a team could score several points: victory earned one point while draw earned half point to each team. To avoid long tedious battles the number of turns per battle was limited by two thousand, after that it was considered a draw. To motivate students to pay attention to debugging their programs, we added the following rule: if the game ends because of an exception, the team which became the reason of it loses.

C# reflection facilities were prohibited to prevent the participants from gaining access to private objects (getting and setting exact enemy positions, health, etc).

Each team had to provide their managed Dynamic Link Library (DLL) and source code. Each DLL was tested for viruses and published after the stage. It allowed students to improve their AI by testing it against the competitors' bots.

4.2 Initial test and organization issues

For better understanding of how to divide students into balanced groups we delivered an initial test. Initial test consisted of ten questions: five question about understanding of AI technologies (e.g. how to find path and make decisions) and five question about Navy and naval principles (e.g. what is a torpedo and how to make direction-finding). Questions are listed below:

- Choose the algorithms that are most effective for pathfinding in graph.
- How can we find the path in some environment (landscape or room) with a given height-map or polygonal mesh.
- Which data structures can be used for pathfinding
- How can you find the best path through the threatened area.
- Choose methods which can be used for decision-making (i.e.)
- What is the difference between a torpedo and a missile?
- Choose the best location for mine-planting.
- What are the advantages of engaging a battle near dry land??
- There is a fixed source of noise and we can find its direction. How can we locate it if we cannot move?
- How can you determine the type of vessel or even concrete vessel by the noise it produces??

Due to optional nature of our tournament not all students took part in this event. We planned to have about five teams with three or four team members in each one, however only three teams took part. Initial test showed a significant difference between students both in understanding of AI technologies and maritime area/branch. We are not sure that knowledge about maritime area is necessary to successfully develop an AI program for our game, but in fact only those students who showed good results in the both parts of the initial test took active part in the contest (Figure 4).

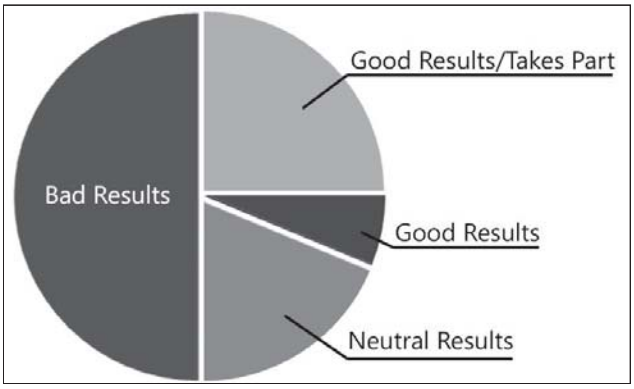

Figure 4: Initial test results

Eventually we got three teams named: ZergRushAI, VeryGoodAI and NukeAI.

Table 1 shows results for each stage of tournament. Table shows total turn count, team names, total launched torpedoes for each team, total placed mines for each team, number of survived submarines and winner. Last column shows winners for each stage.

Table 1. Tournament results

Turns	Team	Torpedoes	Mines	Alive	Team	Torpedoes	Mines	Alive	Winner
Stage I									
364	VeryGoodAI	1	49	1	NukeAI	41	0	0	VeryGoodAI
630	NukeAI	52	0	0	ZergRushAI	17	0	5	ZergRushAI
518	VeryGoodAI	3	37	0	ZergRushAI	38	0	5	ZergRushAI
Stage II									
345	NukeAI	35	0	0	ZergRushAI	94	0	3	ZergRushAI
728	VeryGoodAI	116	108	3	ZergRushAI	117	2	0	VeryGoodAI
1020	ZergRushAI	114	7	0	VeryGoodAI	126	169	2	VeryGoodAI
Stage III									
596	NukeAI	76	0	1	ZergRushAI	18	55	0	NukeAI
467	VeryGoodAI	13	62	0	NukeAI	56	0	4	NukeAI

Turns	Team	Torpedoes	Mines	Alive	Team	Torpedoes	Mines	Alive	Winner
589	VeryGoodAI	9	68	2	ZergRushAI	20	64	0	VeryGoodAI
1907	NukeAI	109	0	4	VeryGoodAI	23	165	0	NukeAI
582	ZergRushAI	12	69	0	NukeAI	74	0	5	NukeAI
521	ZergRushAI	26	77	0	VeryGoodAI	27	69	2	VeryGoodAI
Final Stage									
1052	NukeAI	147	14	2	ZergRushAI	119	52	0	NukeAI
559	VeryGoodAI	86	52	0	NukeAI	88	6	5	NukeAI
770	VeryGoodAI	91	90	0	ZergRushAI	108	58	2	ZergRushAI

After the second stage competitors and spectators supposed that results could be different if bots' initial positions were switched because of the non-symmetrical game map. So, we decided to deliver the third stage with two substages to put teams in the same conditions. But overall stage results were the same and we refused this approach.

In the first stage ZergRush was a winner because they started bot development a little bit earlier and developed good group behavior, mining algorithm and stochastic torpedo launches. NukeAi showed worst results because they did not discover a way to distinguish their own submarines from the enemies and lost all submarines because of "friendly fire" and collisions.

In the second stage VeryGoodAi performed well mostly due to aggressive mining, good aiming algorithm and finite state machine driven behavior selection. They used delayed attack strategy allowing the enemy to approach closer while remaining hidden. NukeAi lost all battles because of program crashes.

In the third stage NukeAi unexpectedly showed good results. They learned competitors' tactics, refused using mines in favor of faster approach to more advantageous positions near the center of the field and implemented multiple strategies which were selected according to battle conditions.

At the end of the tournament each team made a presentation and unveiled their tactics and told the story of their bot development. Each team used unique approach to implement AI behavior. However nobody used two point direction finding for precise target locating.

Our teams showed a great deal of ingenuity and artistic approach to their work. One of the teams attached a soundtrack to their bot, which played during the battle, meanwhile another team used specific markers on the field to inform spectators about what their bot was thinking.

4.3 Post test

After the tournament we surveyed students (both who took part and did not take part in tournament) again. Most significant results were from the students who did not take part in the tournament. Two thirds of the students said that they would like to participate in the next tournament. When the students were asked why they did not take part, vast majority answered that they did not have enough time for that. Questions are listed below:

- Did you take a part in tournament?
- Why did not you take part in the tournament?
- Would you like to participate in this competition again?
- Did you use the opponent's bots to train your bots?
- Rate bot API.
- Write your suggestions for improving the bot API.
- What principles are your AI based on?

5. Discussions and future work

To attract students' attention including those who didn't take part we built up our tournament as a little bit more informal event rather than an ordinary classroom lesson. Each turn induced stormy discussions and applauses. Figure 5 shows the final stage of the tournament with a group of participants and interested students. Projection screens show the current game situation.

Figure 5: Tournament in the classroom

In general we consider this event to be successful, however we met some difficulties. The first major difficulty is students' free time. Students have job and mandatory disciplines and do not have enough time to take part in the tournament. To solve this problem we are going to try to embed this tournament as a coursework for AI discipline.

Another difficulty is high barrier to entry. Some students have no strong knowledge of C# programming language and it is hard for them to get quick results. To tackle this issue we consider three measures. The first one is using a visual domain specific language with binding to conventional programming languages. The second one is to make the game as a HTTP server. Such approach will make the game more protected from cheats and easy to bind different languages like C, C++, Javascript, Java, Python, Lua, etc. And the third measure is to enable "Human vs AI" mode. This approach will lower barrier to entry and make bots easy to debug.

There are several technical problems that remain to be solved. For example it would be interesting to analyze battles in which one specific AI fights against itself. It would give us information about possible map imbalance. Also we would like to be able to launch large numbers of battles with the same participants in parallel to statistically determine the winning AI.

6. Conclusions

In this paper we presented an example of integrating Game Based Learning and competitive programming into the course on Computational Science for the first year master students. We received very positive feedback from the participants as well as from spectators who watched the competition and the final battle on the big screen.

Taking into consideration the acquired experience we are planning to substantially improve both the game environment and the organization matters. In the long run, we expect that this investigation will lead to a more sensible understanding of how to design educational video games that will meet course outcomes, improve retention, and inspire life-long learning skill in our students.

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Students as Digital Games' Evaluators: Enhancing Media Literacy and Learning Through Game Playing and Evaluation Methods

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Abstract: Digital games are recently in constant debate in the educational community on issues such as promoting media education and learning as well as engaging students in activities that enforce subject cognition and effective collaboration learning assignments. At the same time, these particular principles 'serve' the trend of the Media Education. Hence contemporary changes in the wider media field require a re-evaluation of the fundamental aims and methods of media education – not just as far as the content of the curriculum is concerned, but also in terms of a pedagogical method process. In this article, based on the above framework, the researchers are trying to portray the implementation and evaluation of a learning and teaching scenario, in which learners-primary school students are gradually exposed to the role of a video digital games evaluator, learning about them, playing them and gradually setting up the evaluation criteria through the constant coordination of the teacher-facilitator. As a culmination of their efforts, the students evaluate the digital games they selected and played as well as create an on-line journal, on which they demonstrate in both numerical and descriptive ways their outcomes. Via the utilisation of specific guidelines and evaluation criteria to be defined by them, students, evaluate and formulate a review of the characteristics of their favourite video game. Subsequently, based on the assessment panel they compose an analysis, describing the characteristics of the digital games in question as well as attempt to provide advice to prospective users-players on their correct educational integration. Although limitations existed on mapping the evaluation criteria and guiding the students to adopt and promote the required competences, the attractiveness of the tasks in question connected and supported by the careful pre-planning of the scenario seemed to aid the effectiveness of the project. New competences and knowledge developed such as a critical eye on the digital games, evaluation techniques on digital games in learning settings as well as enhancement of cognition on certain issues and subjects.

Keywords: media literacy, learning, students, evaluation, digital games

1. Introduction

The basic principles of the present study are in accordance to the current outcomes and directions of research conducted in Europe regarding the status of New Technologies and New Media in education. Conferring the European "Horizon" Report (Johnson et al. 2014), an increasing focus on the use of both traditional and virtual learning methods is expected to have a strong impact on Europe within the next two or three years. These trends are also identified on a global level for having the potential to stimulate new models of teaching and learning. Ott (2010) argues that there are innovative learning ways which engage and excite students. Harmer (2004) stresses that the improvement of the students' writing skills as well as the practical methods on the stages of the speech production process is obtained by using "Word" on the PC. Hence, the digital media transform traditional forms of media to learning experiences.

At the same time, these particular principles 'serve' the trend of the Media Education. According to Buckingham (2010), contemporary changes in the wider media field require a reevaluation of the fundamental aims and methods of media education – not just as far as the content of the curriculum is concerned, but also in terms of a pedagogical method process. Media education has been established in Europe (Mommers et al. 2013; Oxstrand 2009) and recognized from the UNESCO association (Frau-Meigs 2006; Wilson et al. 2011).

Nowadays, the role and the use of the ICT as well as the Media is gradually recognized in the formation of trends, attitudes and perceptions in the minds of students. Additionally, the media are constantly changing their profile providing data that may be used in education through providing students with specific opportunities so as to learn in a different way (Hasenbrink et al. 2008). Teaching with new technologies requires a clear set of goals and a specific procedure, which helps both students and teachers to focus on target. Wiske et al. (2005) mention *"time with learners is too precious to spend on activities without a clear and important educational purpose"*.

2. Between media education and digital games: The evaluation aspect

Electronic digital games flourished and gained big publicity in the recent years. Thus we refer to a new form of cultural expression that tends to dominate the established means of mass culture, like cinema and television. Moreover, in the fields of the academic society, a considerable interest emerged regarding learning supported by electronic digital games. This interest is evident via the extension of the research that is carried out and the relevant citations.

Through the study of the literature on educational digital games, it seems that there is a large number of reports focusing on their evaluation. These studies could be divided into the following categories. Firstly on studies suggesting specific frameworks and evaluation criteria related to the design and development of educational digital games (Lai-Chong Law et al. 2008; Villalta et al. 2011; Torrente et al. 2015).

Secondly, there are studies that focus on the summative evaluation. These studies evaluate the effect of the usage of digital games on students' learning as regards to their knowledge, their attitudes, and their skills. In this category of studies a number of different methodological approaches is used such as surveys, case studies and experimental studies. Usually these studies evaluate the impact of digital games on learning either by comparing different gaming modes (Girard et al. 2013; Tsai et al. 2015), or by associating the game with certain computer applications (i.e. flash animation) or other digital games and teaching aids (Yang 2015).

In addition, there are game-based learning studies which investigate the effects of digital games' design on pupils' motivation, engagement, game satisfaction and learning while playing an educational game (Filsecker & Hicke 2014). For instance, Ronimus et al. (2015), studied if certain game features have an impact on children's engagement during digital game-based learning of reading and whether they could help to sustain children's engagement over time.

Thirdly, there are studies where students are involved in the evaluation of their own digital games through their participation in their design and development (Robertson & Howells 2008; Triantafyllakos et al. 2011). According to Ke (2015, 27), *"the practice of having students as designers of computer digital games can actively engage learners and offer them opportunities to exercise the skills of digital storytelling, computational thinking, and creative thinking"*.

Fourthly, there are studies in which students play the game and evaluate it in terms of specific criteria such as worthwhileness and ease of use. Usually in these studies the evaluation is supported by technology acceptance models and certain theories of psychology. For instance, Hou and Li (2014), in their study, 67 university students in Taiwan evaluated multiple aspects of a problem-solving-based educational adventure game, Boom Room© using the Technology Acceptance Model and Flow theory. More specifically, these students were asked to complete a pre-test before playing the game and a post-test after playing the game. They provided evaluation of not only the usefulness, ease of use, and design elements of the game but also their experience with various flow dimensions of the game.

According to Filsecker & Hicke (2014, 138) *"players of commercial digital games are developing problem solving and literacy skills and that good commercial digital games represent good learning principles that provide opportunities for gamers to engage actively and reflectively during gameplay"*.

Despite the large number of studies about the evaluation of educational digital games, there are a limited number of studies focusing on the evaluation of commercial digital games by the students themselves. In particular, in literature review, the number of studies where primary school students assess commercial digital games is pretty limited (Vissers et al. 2013).

3. Designing the teaching scenario: Goals and basic elements

Corresponding to the above reasoning, a model educational scenario based on new technologies (e-scenario) was structured and implemented within the frame of the research program "Creation of prototype methodology for educational scenarios based on use of new technologies (ICT and new media) by the Centre of the Greek Language (Thessaloniki, Greece). The scenario was implemented in a considerable number of students (3 classes, totally 61) in the fifth grade (aged 11 years old) of Psychico College of Athens (Spring 2014) and 1st Experimental

Primary School of the Aristotle University of Thessaloniki (winter 2015) within the frame of the subject of Greek Language.

This particular e-scenario proposes an instruction-flexible teaching model, which focuses on highlighting the digital games as a tool in the educational praxis. Concerning the educational scenario *“The lord of digital games! We play and grade digital games!”* the basic aim was for the students to see themselves in the role of evaluator of video games. With key points and evaluation criteria that students had previously defined. Pupils graded and reached through study, practice and collaboration an assessment of the characteristics of one of their favorite or familiar digital games. Following, according to the table of evaluation, they wrote a review, describing the features of the specific digital games, providing also advice to future players regarding the proper use of digital games.

In the present scenario students were gradually introduced in to the role of the evaluator of digital games, learning about them, playing and gradually forming their evaluation criteria. As a result of their attempt students assessed a particular game they studied and played for a long time and then created an e-book in which they presented their conclusions not only in numbers but also in a descriptive way.

3.1 Teaching practices

Cooperating in small groups, students acquired and reinforced their cooperation competences. Multi-sensor methods were developed for the reinforcement of learning. The students functioned with a learning autonomy, visualizing and verbalizing their actions. Through the assessment they were introduced and acquired meta-cognitive competences not only by arriving at an objective and a balanced assessment of their classmates’ tasks (identifying points that can be rewarded and points that can be improved) but also by developing their tasks on a basis of equivalent assessment by their classmates.

3.2 Connection with school’s curriculum

The scenario serves the general aim of the language lesson that is the students’ involvement in teaching methods and digital tools that were angled to inquiry-based learning. Specifically, students who were involved in the educational scenario operate targeting the realization of the objectives included in the Curriculum, like the usage of types of texts for various purposes and various recipients, the distinction of the connection between the purpose of the writer and the form of the language or the speech he/she uses and the writing of small texts by the students based on their world of experience as well.

3.3 Information and communication technologies (ICT)

The scenario includes pedagogical activities of harnessing the ICT tools through which the construction of new knowledge is realized. More specifically the relevant employed tools of teaching and learning were:

- Selected webpages for deriving texts and audiovisual material.
- The word-processing software that is used from the students to organize their ideas, to form and transform their own texts.
- Electronic dictionaries that give the student the facility not only to get familiarized with a modern and essential tool for the language but also to consolidate various and alternative ways of searching.
- A Blog or a class’ web site, in which students can easily publish and visualize their task.

4. The Scenario *In Praxis*

4.1 First session

The first session commenced, all the sessions involve a minimum of two teaching hours’ period, in the classroom setting of the 5th grade (11 years old). During the first session the teacher initiated the e-game based scenario with the selection and reading of a relevant topic from the class’s language book on digital games. All the children participated in all six studies. The teacher read to the students a unit from the school book regarding an electronic soccer game subject. The particular topic immediately engaged students, both boys and girls. Girls were enthusiastic due to the digital form of the game and boys were also excited regarding the sport as well. Subsequently, the whole class contributed in a discussion on personal experiences with group based digital games. Certain questions were raised such as the kind of digital games they like to play, time allocated and reasons for the particular game preferences. The pupils pictured many game titles as well as the digital games' rules and tactics required for consideration and adoption by the gamers with enthusiasm and high levels of participation. Additionally they portrayed great knowledge on those specific e-digital games in terms of rules and tactics, graphics and ways of play. After the diagnostic and introductory in class discussion, the teacher presented to the students the purpose of the e-game scenario project as well as highlighted the evaluation aspects that the pupils in groups will adopt and acquire through the tasks. Thus the class was divided by the teacher-facilitator and the help of the students into groups of 2-4 students. The newly formed groups decided on their group name. Further a video from 'YouTube' video platform on the evolution of the video game FIFA was presented to the students followed by the second part of a discussion on the evolving path of the digital games. A specific representative student statement follows: *"I have learnt from playing the particular game all the rules and tactics, the teams and the tricks you need to follow so as to win the game".*

4.2 Second session

During the second, teaching session the class visited the school's computer lab where the teacher arranged the already formed groups to work in front of specified computers. Previously the teacher copied on the computer's desktop certain files with all the required tasks of the session. The students were asked to open the first task file. The activity required that, through the use of an electronic dictionary, students should read the provided Greek text, titled: *The Video Digital games Yesterday and Today*, concerning the history of video digital games, and then identify and select the foreign words on the text. Successively, they had to copy the selected foreign words from the activity paper, on the computer as well as find the synonyms of the words in the Greek language. The teacher acted as a facilitator and promoter of the task, providing help and guidelines to any team in need. Certain teams had disagreements regarding particular words but were resolved by the teacher-facilitator. After the activity a discussion developed where the new found words and synonyms portrayed by the groups. Any misinterpretations were revised through the following- concluding presentation and discussion activity. Finally all the groups managed to collect the necessary information and each group performed a self-evaluation task according to the activity's guidelines and the overall performance of the team. The evaluation was based on the *Excellent, Very Well, Well and Need of Effort*, rating scale. At first it took time and effort to guide the students in the discovery of the foreign words and the teacher-facilitator intervened in many instances by providing examples and ways of spotting the specific word and the relevant Greek synonyms. Although we faced organisation, collaboration and understanding difficulties with the constant support of the teacher-facilitator we managed to overcome all the obstacles and succeed in the task. A specific representative student statement follows: *"I did not know that all these words have a Greek synonym. I believe that I have enriched my vocabulary and expression skills".*

4.3 Third session

During the third, teaching session and in the computer lab the teacher presented and explained to the students the following activity, a 20 minutes game playing task. The pupils in groups had to play a specific Video Game based on the second activity file. Afterwards they were required to evaluate the specific game based on a provided, in the file, exemplary pattern. The groups evaluated the digital games, pointing out a strong and a weak element of the game, based on certain parameters such as rules of the game, engagement of the gamer, graphics quality, any knowledge gain from the game's activities, any competences required by the gamer, levels of difficulty, resonance and logic of the plot, innovative ideas and creativity employed by the makers, as well as user-friendliness. Subsequently the groups formed a short commentary about 50-80 words according to the guidelines of the task. After the completion of the activity the evaluation results were announced to the class by each group. According to the in class observations and diary of events although they did not know how to start writing a commentary, all the teams participated with great enthusiasm and attempted to construct a complete commentary without any grammatical mistakes in accordance to the guidelines and the given parameters. The teacher facilitator again organised the groups, portrayed the main parts of the commentary and supported each group on any related issues such as queries on the game, as well as any grammar and syntax questions regarding the subject. During the evaluation activity and the discussion session, the majority of the students expressed their interest on the task as well as acknowledged the significance of the newly explored areas of the digital games in question, which as they stated, did not take into account before. These are, as indicated in the activity, the innovative ideas and creativity of the particular game, ways of engagement of the gamer, importance and reason for level difficulty, as well as knowledge and competences acquired by the gamer through the connection of the tasks to the history and facts of the Roman and Greek era. A specific representative student statement follows: "*It seems that I have learnt a lot that I did not know about Roman and Greek history through playing the particular game and it was real fun playing and learning".*

4.4 Fourth session

In the fourth session of the project, a discussion initiated by the teacher in the classroom setting on the need to evaluate video digital games. The pupils agreed that the evaluating process on the video digital games enlightened them of certain parameters they were not familiar with. Furthermore they indicated that they are now more knowledgeable of the properties of the digital games in question as well as the knowledge and competences they could transfer to them. In addition they expressed the wish to evaluate, well-known digital games to them and to inform and present their findings on an electronic board-blog, as well as to advise the other school students, in a forthcoming School Fair on Digital games and Game Culture. Subsequently and on the class's Interactive Whiteboard each team presented strong and weak elements of the specific game they evaluated. Additionally, a brainstorming procedure followed, involving the creation and selection of the principal evaluation criteria by the students themselves. All the criteria were noted, collected and organized by the teacher into one main evaluation framework. Furthermore each group selected a video game and explained to the other students in the class, the reasons for the selection and the potentials-knowledge and skills that might be gained from playing the game in question. A specific representative student statement follows: "*I have gained a lot regarding ways of evaluating a game as well as building on skills and knowledge from the game and the tasks I have to complete".*

4.5 Fifth session

Following and in the fifth work session, the students opened the file including the game evaluation framework (Table 1) and proceeded to the evaluation of a game they have played and known. The file presented a rubric pattern where students need to grade the game on specified areas. Originally and in groups, pupils discussed the game in question regarding strong and weak elements of the game, factors that influence the importance of the game in terms of engagement levels, knowledge and skills acquisition as well as levels of difficulty and justification, attractive graphics and the player's ease of use and navigation. Furthermore, they search through Google to find any related to the game information that could support their study.

Table 1: Evaluation framework

Evaluation Framework	None (0)	Little (5)	Enough (10)	Very (15)	Very Much (20)
Specifications (graphics, sound effects, music, 'Multiplayer », 3D, online features)					
Quality Characteristics (action, script, object, learning, ease of handling, positive messages, other)					
Relationship with Reality (society, history, environment, realism, sports, relationship with film -book)					
Emotional Balance (creativity, self-expression, imagination, VS stress, competition, immorality)					
Negative Attributes (violence, war, addiction, bad examples, vocabulary, gambling, sexist elements, other)					

Afterwards the pupils filled the evaluation template with all the relevant information they have learned through the playing experience, the related web sites and the in group discussion. They also calculated the total ranking for the game in question and composed a short text on the evaluation factors and principal characteristics of the game. The specific terminology in the table helped the students to express correctly their arguments utilising suitable wording as well as expressions and thus building on their written and oral skills. Although some children did not understand the task at the beginning the groups supporting each member and with the constant support of the teacher-facilitator managed to overcome any difficulties and complete the given tasks.

4.6 Sixth session

In the sixth and final session of the project the students entered the school's web site and visited the link related to the project. The teacher previously designed and created an on line journal-blog on video game evaluation where pupils could upload their activities and presentations on e-game evaluation techniques as well as skills and knowledge gain. Thereafter they all moved to the class where a vivid discussion on the experiences and overall evaluation practices on video digital games took place. Students debated with enthusiasm on the issues and ways of evaluating video digital games as well as portrayed and argued about the skills and knowledge gained from the activities. Representative student statements follow:

- "I have gained in skills and knowledge through the research activities and playing experiences".
- "I have increased my vocabulary and writer techniques on the subject as well as discovered issues and parameters of the digital games I did not know".
- "I can now learn from game playing and also be able to select the proper digital games for education as well as fun".
- "I can understand now how to avoid the negative attributes of the digital games and gain from the positive and quality characteristics of specific digital games".

In the concluding session the teacher-coordinator portrayed the activities from the introduction of the project in a time-lined route presentation. Discussion followed and ideas on promoting the artefacts produced during the project were presented. A wall panel with all the written products was crafted outside the class. Likewise the poster of the on line journal-blog was also distributed, informing the pupils in the school. Additionally the students discussed with their school mates about their experiences on the project and the purpose of the on line journal- blog. As a result an interesting and active commentary on the issues in question started on the blog's wall. Moreover preparations for the forthcoming school's fair on video digital games and evaluation techniques commenced through the teams.

5. Conclusion

It seems that digital games need to take into account the prospect of effectively permeate and pervade into educational systems. For the time being they are mostly used in commercial and experimental settings and thus they are unable to benefit and support today's educational pedagogies. However, with the development and deployment of evaluative methods brainstormed, designed and implemented by primary school students, according to the educational practice described in the article, certain factors emerged. User engagement and the provision of specific learning opportunities seemed highly possible. Certain competences developed by the students promoted particular educational benefits such as knowledge of the subjects portrayed in selected digital games, according to their educational and cognitive value. Students through the teacher's guidance acquired critical and media literacy skills as well as evaluated accordingly selected digital games. The process changed students' previous perceptions regarding digital games and playing modes as well as unlocked a new world of how, why, and with which purpose to play digital games so as to gain cognition and skills through fun ways. Students also promoted autonomy and initiatives as well as the skill to learn through playing specific digital games. Future work could focus on the implementation and evaluation criteria of game based learning modes, levels and subjects as well as entail further improvement evaluation factors based on the teaching and learning methodology proposed in the article. With a more wide and varied spectrum of digital games, as well as an extended number of evaluation criteria on educational digital games and learning modes we could, ultimately alter stances and attitudes towards implementation of digital games in education as well as enrich the filed on educational methods in accordance to digital games design and creation.

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The Ludic and Narrative Components in Game Based Learning: A Classroom Training Experience

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Abstract: This paper addresses the relationship between ludic and narrative components in a game-based classroom training experience, and their role as mediators in the relationship between level of satisfaction and learning. The study was conducted on a sample of 62 users, through a set of workshops where Lego® Serious Play® method was enriched with a narrative structure, based on role-playing session. Considering the Ludology - Narratology debate, this paper is a further study which aims to investigate, empirically, the role of both elements in serious games and, consequently, in learning. A first confirmatory factor analysis was conducted to verify that the two factors, namely the ludic and the narrative one, could be used to cluster the measured variables. Then, a path analysis showed the relationship among all the variables. The study showed, as first result, that the degree of satisfaction is the main predictor of the learning results and that the influence of narrative and ludic components on the player experience are really alike, with a slight dominance of the ludic one. The second result is that the mediation of the game components, both of the ludic and of the narrative one, has an unbalanced structure. One of the interpretation of this result is that the relationship between satisfaction and game mechanics is stronger than the relationship between game mechanics and learning. In other words, part of the engagement and enjoyment that is produced by the game context does not result in effective learning.

Keywords: serious games, narrative, ludology, role playing game

1. Introduction

According to Knowles (1973) when it comes to adult education, learners motivation, previous knowledge, experiences and interest are fundamental for the training process to be effective. In order to engage adult learners, as stated by Dewey (1938), it is important to challenge them with activities able to catch their attention and to be connected with practical experience. The Learning by Doing paradigm, according to Aldrich (2007) has shown good results in engaging adult learners. Considering games as an application of this paradigm, many studies have demonstrated that game, according to Huizinga (2014) has an important role in learning processes, especially those based on direct interactions, as stated by Aldrich (2007) and Dewey (2004): thus it is important to see how the playful approach can be an incentive in adult education.

In this sense, we can consider Serious Games, both digital and not, as an effective way to perform adult education. They are made up mainly of two parts, the narrative one and the game one, which, combined, generate products that can capture the attention of the learner. The relationships of interdependence between game and narrative component, according to Ryan (2001), have unraveled the debate between Ludology and Narratology, according to Amory (2007): the ludologic position arguing that the game is made up mainly by rules and gameplay, and that therefore the narrative plays in it a marginal position, as stated by Frasca (2003); on the other hand, the narratological position affirms that games are nothing if not a form of storytelling and must therefore be treated according to the rules of the narrative, according to Juul (2001).

In a previous study about the InTouch Project, as stated by Imbellone et al (2015), was investigated how the ludic and narratological components affect the willing to play again of the players.

One of the expressions of the ludic element in training is represented by the Lego® Serious Play® method: as on the Open Source/<Introduction to Lego® Serious Play® (2010), the method is open source, and was built to guide meetings and to help to manage communication and problem-solving processes. Participants have to build their own model with Lego® bricks and then to discuss the model with the others. For our study we decided to keep the building action of the Lego® Serious Play® method, even if a different scenario, in order to involve students in playing activities, also fostering a different way to think to what they are learning.

On the other hand, as stated by Thabet (2015) we know how Role Playing Games narrative can be compelling for the players: assuming a role and follow a story is the core of those kind of games.

This paper presents the results of a Lego® Serious Play®-inspired application, realized through a set of workshops where the standard Lego® Serious Play® method was enriched with role-playing elements. The driving motivation for the study was to analyze how the use of a serious game approach in an educational context, explicitly containing ludic and narrative components, can influence the relationship between satisfaction and learning. Section 2 will illustrate the approach that was adopted; Section 3 will illustrate scope and hypotheses of the present study; Section 4 will deal with statistical methods; Section 5 will illustrate results; Section 6 will draw conclusion and future work perspectives.

2. The classroom training experience

For our study we decided to test the blended model in 5 workshops, for a total of 62 participants.

We wanted to test how the narrative and ludic components of a training experience could affect the relationship between satisfaction and learning, considering the Lego® building activity as an expression of the ludic element and the role playing part as expression of the narrative one.

Inspired by the official Lego® Serious Play® method, as described in Open Source/<Introduction to Lego® Serious Play® (2010), we chose to adopt the construction element with Lego® bricks, even if in a different workshop structure, in order to make the learners play, encouraging a different mental activity, as stated by Sousa (2011), fostered by practical manipulation of elements to represent abstract concepts or product features. On the other hand, we decided to use the typical role playing games elements, like narrative, roles and development of the story, to engage students in the narrative flow.

2.1 Scenario

The topic of the workshop was the basic elements useful to build a communication strategy for a new product to be sold on the market.

Considering this, the starting scenario concerned a typical communication context: a Company (the client), operating in the field of green technology, had to sell its new product. All the product features were described in order to build the communication strategy.

2.2 Teams and rules

The participants were divided in two teams, each one representing a communication agency with different experience and expertise. Each participant had a professional role in the agency, useful to accomplish the missions assigned during the workshop.

Two facilitators were involved: one teaching the contents and coordinating the students through the game sessions, and one representing the client who had to choose one of the two communication companies to promote his new product on the market.

There were also a set of rules, to assign points, badges and rewards, and a set of *missions*, to be accomplished in order to gain points and badges.

The team with the major amount of points at the end of the workshop was the one who won the challenge.

2.3 Workshop structure

The workshop foresaw a succession of teaching moments, play moments and debrief moments.

During the teaching moments the facilitator explained to the students the theoretical contents useful to accomplish the related mission. It is also the moment in which the goal of the mission is explained.

After that, the two teams had to build with Lego® bricks the strategy element to be presented to the client. They had 5 minutes to achieve each task.

The final moment is the debrief: the teams, through a spoken person chosen in turn, had to explain their choices and motivations to the client. After that, the client analysed with all the participants what has been told, assigning the points for the game.

This scheme was repeated for a total of five challenges.

The last challenge consisted of put into practice what learned until that moment in order to, literally, build the best communication strategy for the product.

The trait d'union of all the phases was the story, designed to give significance to the players' actions.

3. Scope and hypothesis

The present study concentrates on the study of the role of ludic and narrative components of the Lego® Serious Play® -inspired method in the causal relationship between satisfaction and learning.

The evaluation of the method was done through the following measured variables: degree of satisfaction about (a) the workshop on the whole, (b) the serious play rules, (c) the serious play gameplay, (d) the serious play system of badges, (e) the role playing system, (f) the narrative of the starting scenario, (g) the development of the narration during the workshop, (h) the learning results.

The choice of the variables was done with a causal model in mind, where variable (a), namely the degree of satisfaction about the workshop on the whole, has the role of predictor, and variable (h), namely the learning results, has the role of final outcome. The other variables are hypothesized to be mediators in the cause-effect relationship between (a) and (h). In particular, these mediating variables are classified as ludic mediators (namely the serious play rules, the serious play gameplay, the serious play system of badges) and narrative ones (namely the role playing system, the narrative of the starting scenario, the development of the narration during the workshop).

Together with the intuitive hypothesis of a positive direct influence of satisfaction on learning, it was hypothesized a significant mediation of this relationship exercised both by ludic variables (namely: the serious play rules, the serious play gameplay, the serious play system of badges) and by the narrative variables (namely: the role playing system, the narrative of the starting scenario, the development of the narration during the workshop). The causal scheme is represented in Figure 1, where all paths are numbered for future references in the following of this paper.

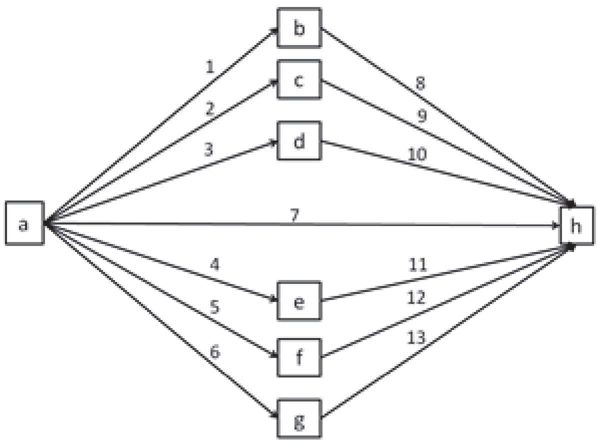

Figure 1: Causal model with 8 variables (a, b, c, d, e, f, g, h)

4. Methods

This section contains an illustration of the methodology that has been adopted in the present study: a description of the sample; the research procedure; the instruments and the statistical analyses that were adopted.

4.1 Participants

The target sample consisted of 62 high school students who took part to 5 different workshops organized in the framework of the open days of the Digital Communication Faculty at Link Campus University (Rome, March – April 2015). The students were selected on the basis of their willingness to participate in the workshops. The mean age was 18.3 years (SD = 0.9), 55.3% females and 44.7% males.

4.2 Procedures

To evaluate the impact of the workshop a questionnaire was proposed to participants at the end of each workshop. Participation was obtained through an informed consent procedure asking for active consent from students. Questionnaires were administered in the classroom and took approximately 10 min to complete. The facilitators introduced the questionnaires, giving instructions on their compilation, explaining that they were voluntary and responses were anonymous and confidential. Experts were at the students' disposal during the questionnaires' administration to answer questions and give an explanation. All students responded to the same questionnaire packet.

4.3 Measures and data analysis

A questionnaire was proposed to participants, after the completion of the workshop, asking them to express on a 5 point Likert scale their degree of satisfaction about (a) the workshop on the whole, (b) the serious play rules, (c) the serious play gameplay, (d) the serious play system of badges, (e) the role playing system, (f) the narrative of the starting scenario, (g) the development of the narration during the workshop, (h) the learning results.

4.3.1 Preliminary analysis

As a preliminary analysis, skewness and kurtosis were checked. Overall, all variables showed to conform to the normal distribution.

4.3.2 Correlation

As a first step, the correlation matrix of all the variables measured by the questionnaire was calculated.

4.3.3 Confirmatory factor analysis

A confirmatory factor analysis was conducted to verify that two factors, namely the ludic and the narrative one, could be used to cluster the six measured variables (b), (c), (d), (e), (f), (g). In particular the ludic indicators were hypothesized to be variables (b) the serious play rules, (c) the serious play gameplay, (d) the serious play system of badges; and the narrative indicators were hypothesized to be variables (e) the role playing system, (f) the narrative of the starting scenario, (g) the development of the narration during the workshop.

4.3.4 Path analysis

A path model involving all the 8 variables was analyzed with LISREL, developed by Joreskog & Sorbom (2006), using maximum likelihood estimation procedures.

The R-square percentage of variance of the learning results explained by the model was reported, to estimate the completeness of the considered set of predictors.

5. Results

Table 1 reports correlation coefficients among the degree of satisfaction about (a) the workshop on the whole, (b) the serious play rules, (c) the serious play gameplay, (d) the serious play system of badges, (e) the role playing system, (f) the narrative of the starting scenario, (g) the development of the narration during the workshop, (h) the learning results.

Table 1: Correlation matrix (sub-diagonal coefficients)

Variable	a	b	c	d	e	f	g	h
a	1.00							
b	0.48	1.00						
c	0.45	0.68	1.00					

Variable	a	b	c	d	e	f	g	h
d	0.42	0.48	0.68	1.00				
e	0.31	0.21	0.10	0.00	1.00			
f	0.30	0.02	0.20	0.13	0.67	1.00		
g	0.29	0.11	0.01	0.20	0.51	0.69	1.00	
h	0.78	0.60	0.60	0.59	0.59	0.60	0.59	1.00

Figure 2 reports the results of the confirmatory factor analysis with two factors (ludic and narrative) for the six variables (b) the serious play rules, (c) the serious play gameplay, (d) the serious play system of badges; and the narrative indicators were hypothesized to be variables (e) the role playing system, (f) the narrative of the starting scenario, (g) the development of the narration during the workshop. Fit indexes are: Chi-square = 7.36, RMSEA = 0.19, Non-Normed Fit Index (NNFI) = 0.77, Comparative Fit Index (CFI) = 0.99. The subdivision in ludic and narrative nature of the considered six variables is adequately confirmed by the considered data.

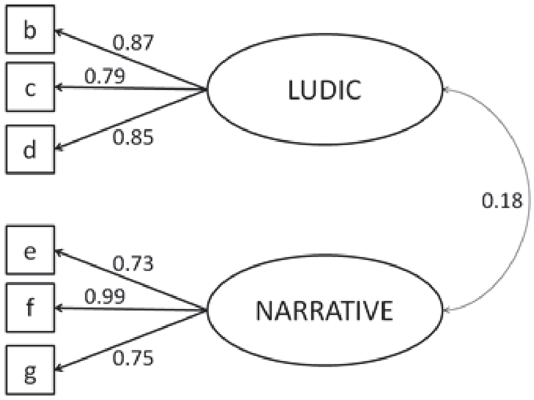

Figure 2: Confirmatory factor analysis results

Table 2 reports the results of the path analysis, with the same path numbers as in Figure 1, for the tested model with the levels of significance of the causal paths (p-values) indicated in the table footnote. The last column reports the R-squared value for the degree of satisfaction about the learning results. All the path coefficients linking the degree of satisfaction with the ludic and narrative variables (numbered from 1 to 6) resulted to be significant. The casual path number 7 linking the degree of satisfaction to the learning results is significant as well. On the contrary the path coefficients linking the ludic and narrative variables to the learning results (numbered from 8 to 13) are lower and in many cases they are not significant.

Table 2: Path analysis coefficients and R-squared value

Path	1	2	3	4	5	6	7	8	9	10	11	12	13	R^2 Learning results
	0.48*	0.45*	0.42*	0.31*	0.30*	0.29*	0.39*	0.15	0.13	0.21**	0.23**	0.13	0.21**	0.93*

* $p < 0.01$; ** $p < 0.05$.

The effect of the degree of satisfaction about the course on the learning results is reported in Table 3, where the total effect is specified as the sum of a direct effect (path 7), and two indirect effects: the one obtained through the ludic variables b, c, d; and the one obtained through the narrative variables e, f, g. The level of significance is indicated in the table footnote. Both the direct and the indirect effects resulted to be significant, even if in a different measure, with a prevalence of the direct effect, followed by the mediation of the ludic variables and lastly by the mediation of the narrative variables.

Table 3: Effect of satisfaction on the learning results

Total	Direct	Indirect through ludic variables b, c, d	Indirect through narrative variables e, f, g
0.78*	0.39*	0.22**	0.17

* $p < 0.01$; ** $p < 0.05$.

6. In conclusion

The R-square value of the Learning results was very high (93% of the variance explained). This can be seen as an overall confirmation of the right choice of the models' variables and their causal arrangement.

The main part as predictor of the Learning results was directly exercised by the degree of satisfaction. However a significant contribution resulted also by the mediation of the ludic variables, while the mediation exercised by the narrative variables is not significant. Similar results were found in the previous study about the InTouch Project, as stated in Imbellone et al (2015). The influence of narrative and ludic components on the player experience are really alike, with a slight dominance of the ludic one.

It must be noted that the mediation of the game components, both of the ludic and of the narrative ones, has an unbalanced structure: the causal paths linked to the degree of satisfaction (numbered from 1 to 6) are stronger than those linked to the learning results (numbered from 8 to 13). This result can be interpreted hypothesizing that the relationship between satisfaction and game mechanics is stronger than the relationship between game mechanics and learning. In other words, part of the engagement and enjoyment that is produced by the game context does not result in effective learning. This is a typical situation for educational serious games, where the challenge is indeed to foster the learning through the game, efficiently dosing the playful elements and the pedagogical ones. The balance must be the right way between learning without joy and enjoying without learning. In our specific study we addressed that will be important to improve the balance between the learning activities and the playful ones, in order to reach the right level of involvement of the students thanks to the play, without distracting them from the matters we want to be learned.

The relationship between satisfaction and learning was analyzed under different points of view. The most consistent part of literature about this subject focused on measuring levels of satisfaction according to different course delivery methods, i.e. face-to-face, at distance, blended (Duque and Weeks, 2010; Lakhal, Khechine, and Pascot, 2014). Another part of literature considered satisfaction as a part of learning outcomes, thus analyzing it as an effect of different predictors, like for instance some characteristic of the instructional design, the level of cooperation and/or collaboration within a course, etc. (Glass and Sue, 2008; Lo, 2010; Zhu, 2012; Lee et al. 2011). Some other studies considered the satisfaction as a facilitator of learning (Eom, Wen, and Ashill, 2006; Johnson, Hornik, and Salas, 2008; Eom and Arbaugh, 2011; Lee and Choi, 2013).

The present study concentrates on the causal role of satisfaction as a predictor of perceived learning, demonstrating its significant contribution in fostering learning. The game-based framework functioned as a facilitating context for the development of such a relationship, with a significant contribution of satisfaction on learning both directly and through the game mechanics. It can be hypothesized, and deserves to be further studied, that game-based learning enhances the importance of satisfaction in the learning process, not only as a final outcome, but as a factor that can improve learning.

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Mathematical Self-Efficacy as a Determinant of Successful Learning of Mental Models From Computerized Materials

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Abstract: Computerized animations, simulations and games are useful tools for supporting acquisition of mental models. Various personal characteristics, such as prior knowledge and spatial abilities, can influence, in various ways, effectivity of learning from these materials. In comparative studies with between-subject design that investigate learning effects of these materials, it is important to control for these variables because they should be taken as covariates in case the two (or more) research groups are not sampled equally (which happens even in the case of random assignment of participants to the research groups). In addition, it would be useful to have interventions that measure these variables with as few items as possible; to avoid unbearably long questionnaires. In this initial exploratory study we investigate if mathematical self-efficacy, measured by a single question, and self-assessed ability of acquiring mental models (SAAMM), also measured by a single question, predicts learning outcomes; as concerns mental models acquisition. Re-analyzing data from our four recent studies on one of the well-known principles of multimedia learning, personalization principle (N = 75, 85, 76, 41; college students with diverse background), we show that mathematical self-efficacy and SAAMM are moderately correlated (r = .32 - .40) and indeed related to learning outcomes, measured by transfer tests (r = .22 - .57 and .28 - .48, respectively). However, the reasons behind these relationships seem to be complex and diverse, and at least partly dependent on treatments' characteristics. For a complex simulation using graphs and resembling an educational computer game, this relationship can be, to a large extent, explained by mutual relationships between graphing skills, frequency of game-playing, mathematical self-efficacy, SAAMM, and learning outcomes. For a short animation on an electrophysical topic, it can be explained by mutual links between prior electrophysical knowledge, mathematical self-efficacy, SAAMM, and learning outcomes. Only for a short animation on a math/physics-unrelated topic, we could not explain the relationship between mathematical self-efficacy, SAAMM, and learning outcomes by a third variable (however, the graphing test was not administered in this case). In general, this study indicates that our two questions for assessing mathematical self-efficacy and SAAMM are promising instruments for measuring variables that should be controlled for in studies on learning effects of computerized materials with between-subject design, but more research is needed to pin down details.

Keywords: mental models, mathematical self-efficacy, learning outcomes, animations, simulations, serious games

1. Introduction

Advantages of well-developed computerized animations and simulations for supporting construction of new mental models are well known (e.g., Mayer, 2009; Papert, 1980; Wouters et al., 2013). The process of learning complex knowledge representations (rather than facts or skills) can be conceptualized within the Cognitive Theory of Multimedia Learning (Mayer, 2009): construction of new knowledge happens through processing of incoming information, its organizing into meaningful temporal representations in working memory and integration of these representations with prior knowledge structures in long-term memory. This process is influenced in various ways by learners' characteristics, such as spatial abilities (Höffler, 2010) or prior knowledge (Mayer, 2009).

Both mathematical abilities and their self-assessments predict performance in certain complex skill acquisition tasks (e.g., Ackerman et al., 1995; see also Hacket & Betz, 1989), but studies demonstrating analogical results concerning mental models acquisition are unknown to us. Yet one can speculate that persons who readily manipulate abstract mathematical objects in their working memory can be better at manipulating any (non-verbal) mental object in their working memory, which is, according to the Cognitive Theory of Multimedia Learning, a learning advantage. Mathematical self-efficacy (MATHSE) can thus be one of determinants of mental models acquisition. Besides theoretical implications, if we measure MATHSE with a single question and find a MATHSE—learning outcomes relationship, we would have in hands a simple instrument for predicting test scores. This would bring researchers a substantial aid in comparative studies with between-subject design that investigate learning effects of computerized materials supporting construction of mental models, because the outcomes of this question for individual participants can assist in assigning the participants to study groups (one should either equalize groups on the MATHSE variable or take MATHSE as a covariate in the analysis).

Likewise, we can ask participants on their self-assessed ability of acquiring mental models (SAAMM) prior to the intervention. Having a single SAAMM question would have similar advantages to a single MATHSE question; provided the SAAMM question predicts learning outcomes, as concerns mental models acquisition.

The goal of this paper is to re-analyze data from our four studies (researching personalization principle (Mayer, 2009) in new contexts) from the perspective of the math self-efficacy—mental models learning link and the SAAMM—mental models learning link. We devised one SAAMM question and one MATHSE question (see Table 1), administered it (with other questions) prior to each intervention and correlated it with test scores (obtained after the intervention) and with several other variables.

In the next section, we briefly introduce the personalization principle we originally studied (in order to describe the context). Afterwards, we describe the interventions we used and details of our four studies. Finally, we present the results of the current analysis and its implications.

Table 1: Math self-efficacy and Self-assessed ability of acquiring mental models questions.

MATHSE and SAAMM questions		
Question	Text	Scale
Math self-efficacy (MATHSE)	"Check one of the following to indicate your knowledge of mathematics..."	1 – very small; 6 – very large; Likert scale
Self-assessed ability of acquiring mental models (SAAMM)	"Imagine you will be examined on the history of shipping traffic in the 19th century. A week before the exam, the examiner proposes you that you can learn just one of the following two things: a) the names of British steamboats from the second half of the 19th century, including their displacement and their propeller type, or b) how these steamboats' propellers work. There are over sixty of steamboats and five functionally-distinct types of propellers. What would you prefer to learn?"	1 – definitely (a); 7 – definitely (b); Likert scale

2. Personalization principle

Personalization principle is one of the well-known principles of multimedia learning (Mayer, 2009). These principles can be taken as guidelines for designers developing multimedia learning materials. Multimedia learning materials are defined, in this context, as computerized or non-computerized materials that combine texts and pictures; including books, animations, simulations and games for learning (cf. Clark & Mayer, 2011).

Personalization principle states that learners will learn better when textual instructions are in a conversational style compared to instructions given in a formal/neutral style. There are more possible explanations for this principle, including the increase of the learners' interest and the presence of social cues in the personalized instructions. A recent meta-analysis (Ginns, Martin, & Marsh, 2013) reported that the effect of personalization is robust and statistically reliable (Cohen's d = 0.54; as concerns deep understanding); however, certain boundary conditions remain to be investigated. These include personalization in languages other than English or longer treatments (longer than 35 min – such as complex simulations or games).

The original purpose of our research project was to investigate the personalization principle in the Czech language. To this end, we run four studies with college audience comparing learning effectiveness of computerized learning materials with personalized vs. non-personalized instructions (i.e., the between-subject design). At the same time, we investigated various supplementary research questions, one of them being if self-assessed ability of acquiring mental models and math self-efficacy predict test scores. The motivation behind this question is stated in Sec. 1. We could address this particular question easily because our participants' pools included students with high as well as low mathematical knowledge.

As already said, the purpose of this particular paper is to re-analyse data from our four experiments on personalization principle from the perspective of the hypothetical link between MATHSE/SAAMM and learning outcomes. In general, we found only small differences between our personalized and non-personalized conditions. Therefore, for present purposes, data from the two conditions were collapsed for each experiment.

3. Method

3.1 Participants

Participants were Czech college students (Mean age = 22.72; SD = 3.53) with intentionally diverse backgrounds (primarily computer science, psychology, and arts) and predominantly low prior knowledge of the topic of the respective intervention. They participated for course credit in one of four studies on personalization principle (N = 75, 85, 76, 41; for Experiment 1 – 4, respectively).

3.2 Interventions

Each participant interacted with one of the following computerized material: in Experiment 1 and 2, it was a 2-3 hours long computer simulation resembling a serious game on the topic of beer brewing; in Experiment 3, it was a few minutes long animation explaining the process of lightning formation; in Experiment 4, it was a comparable animation on functioning of biological wastewater treatment plant. In each experiment, each participant received either personalized or non-personalized version of the intervention.

3.2.1 Beer brewing simulation

The intervention for Experiments 1 and 2 was a 2-3 hours long computer simulation, in which the learner's goal was to acquire a mental model of the beer brewing process, as described in detail in (Brom et al., 2014). The simulation is for a single user, it is interactive and, as concerns its complexity, resembles a computer game with schematic graphic (Figure 1). The graphical user interface consists of the several elements, including: textual instructions, an animation panel showing the content of the fermentation vessel, a supplementary explanation panel relaying the meaning of graphical elements, panels with graphs and histograms showing the amount of ingredients in the product, an adjustable thermometer, and buttons for controlling the processes. The simulation also provides feedback via an "assessment" button. The non-personalized instructions have, in total, 6,750 words; the personalized version is slightly longer (the differences between the personalized and non-personalized instructions are unimportant for present purposes; they are detailed in Brom et al., 2014).

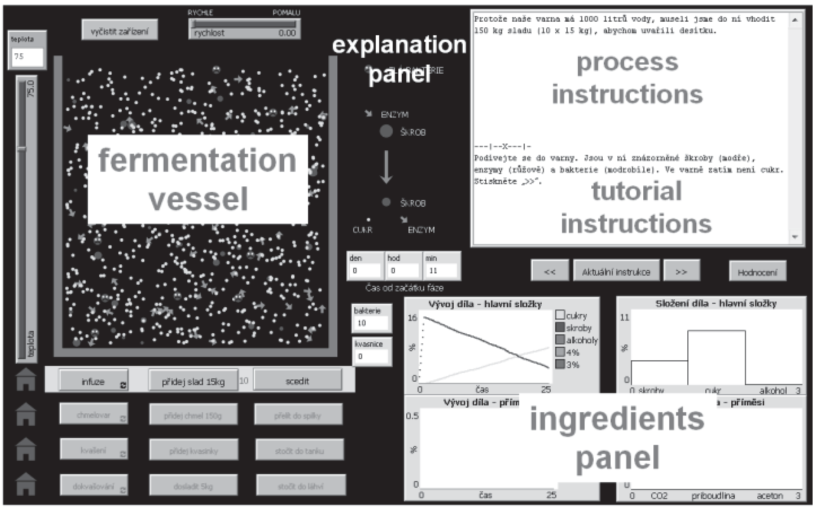

Figure 1: Screenshot of the beer brewing simulation used in Experiment 1 and 2. The main elements of the graphical interface are described. The instructions are in Czech. Note that the "ingredients panel" is composed of two graphs and two histograms). Also note that the interface is in colour in the application

The whole simulation has four parts. These parts include a) a tutorial, b) a segment that demonstrates in a linear fashion how to brew beer from beginning to end, when every step is done correctly, c) a segment that demonstrates the consequences of making errors of not following the standard procedure and d) a segment in which the learner has to brew his/her several beers of a specific type in the virtual brewery. The phenomenon being modelled – the process of beer brewing – is motivating enough for participants to stay with the simulation over the whole period (Brom et al., 2014).

The simulation, including textual instructions, was developed by the research team solely for research purposes.

3.2.2 Lightning formation animation

The intervention for Experiment 3 was a black-and-white, few minutes long animation explain the process of lightning formation. The experiment was a (so far unpublished) replication of the original experiment on personalization principle by Moreno & Mayer (2000; Exp. 1, 2) in Czech context. Therefore, the animation is as accurate replica of the original animation as possible[1] and the instructions are translated from the original animation.

The animation features 16 screens and each screen displays instructions at the bottom of the screen (Figure 2). The non-personalized instructions have, in total, 260 words; the personalized version is slightly longer. The user can only proceed forward – by clicking the "next" button (otherwise, the animation is non-interactive).

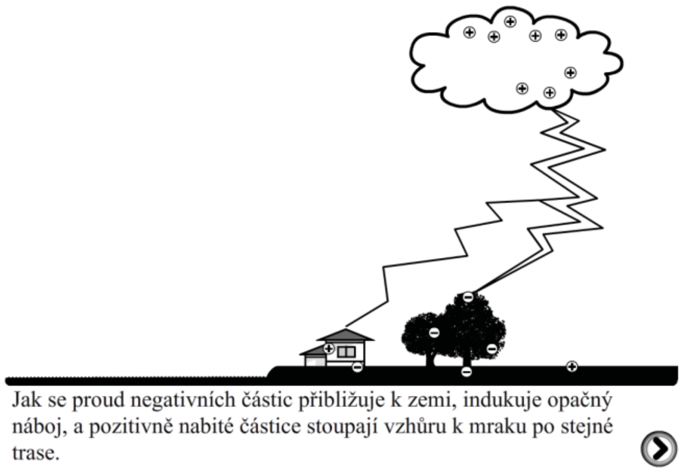

Figure 2: Screenshot of the lightning formation animation used in Experiment 3 (instructions in Czech). The "next" button is in the bottom right corner

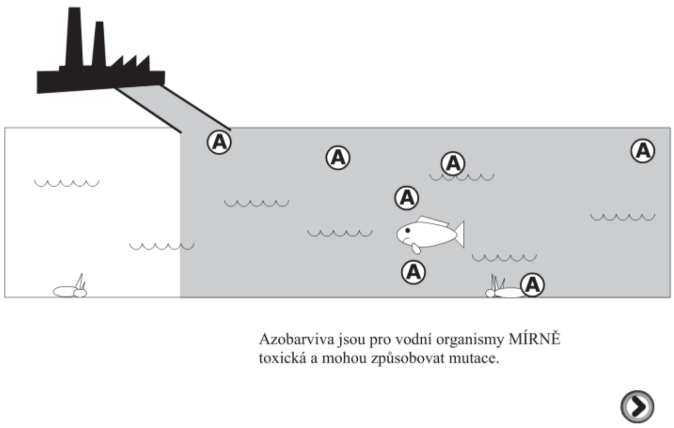

Figure 3: Screenshot of the biological wastewater treatment plant animation used in Experiment 4 (instructions in Czech). The "next" button is in the bottom right corner

3.2.3 Biological wastewater treatment plant animation

In Experiment 4, we attempted to replicate Experiment 3 with a different, yet highly comparable, animation. For this purpose, we created a black-and-white animation on functioning of biological wastewater treatment plant. This animation is, again, a few minutes long. It features 19 screens, each with instructions at the bottom of the screen (Figure 3). The non-personalized instructions have, in total, 300 words; the personalized version is slightly longer. The user can, again, interact with the animation only by clicking the "next" button.

[1] Discussed with the author of the original experiment (email from R. Mayer, 15th March, 2013).

3.3 Procedure and pen-and-paper materials

For each of the four experiments, the following applied. Prior to intervention, participants were administered self-assessment pre-tests with about seven questions of the following type: "Please, indicate your knowledge of X on the scale 1 – very small; 6 – very large." (see Brom et al., 2014 for the beer brewing pre-test; the pre-test for the lightning formation animation was from electro-physics, and it was from wastewater treatment and organic chemistry for the biological wastewater treatment animation – the latter two pre-tests were modelled according to Moreno & Mayer, 2000). The participants also received (among others) the following key questions: on math self-efficacy and self-assessed ability of acquiring mental models (denoted as MATHSE and SAAMM variables; see Table 1 for exact wording), and on computer game-playing frequency (denoted as Games variable; Scale 1 (less than 1 h a week) – 4 (more than 10 h a week)).

Afterwards, the participants interfaced with the intervention; and they proceeded at their own pace. Immediately after the intervention, the participants received knowledge post-tests. Every participant received (among others) a transfer test with four to seven (depending on the intervention) open-ended questions (Transfer variable). Transfer tests are particularly well suited for investigation of understanding of a process/model and they are gold standard in the field of multimedia learning (Mayer, 2009) (see Brom et al., 2014, for details concerning the beer brewing test, and Moreno & Mayer, 2000, for the details concerning the lightning formation test; the structure of the wastewater treatment plant test mirrored the lightning formation test). The tests were graded based on pre-prepared list of idea units; each idea unit was rewarded 1 point and partially correct idea units .25 or .5 points (exact wording was not required). The learners could obtain up to 32 (Exp. 1, 2), 20 (Exp. 3) or 25 (Exp. 4) points.

In the case of the beer brewing simulation (Exp. 1, 2), participants also returned to the laboratory one month later to complete the second round of knowledge tests, including the transfer test (see Brom et al., 2014 for details). Therefore, in the present analysis, transfer tests scores, for Experiments 1 and 2, are taken as the average of the scores from the immediate and delayed transfer tests. In the delayed testing session, participants also received a graphing test (Graphing variable; Scale 0 (nothing) – 9 (maximum)) and, in Experiment 2, also a brief test of 2D spatial visualization skills (Spatial variable; Scale 0 (nothing) – 7 (maximum)). The graphing test is a shortened version of the test of McKenzie & Padilla (1986) and the spatial visualization skills is a shortened version of the test of Slezakova & Molnar (2011).

3.4 Data analysis

Since the data from the two conditions were collapsed for present purposes, we did not use condition as an independent variable. We thus used the following linear regression model for explaining the transfer test scores:

$$Y_i\,(\text{transfer}) = \beta_0 + \beta_1\, Pretest_i + \beta_2\, MATHSE_i + \beta_3\, SAAMM_i + \beta_4\, Games_i + \beta_5\, Graphing_i + \beta_6\, Spatial_i + \varepsilon_i,$$

where $Pretest_i$, $MATHSE_i$, $SAAMM_i$, $Games_i$, $Graphing_i$, and $Spatial_i$ are variables for i-th student, Y_i (transfer) is transfer test score for *i*-th student, and $\varepsilon_i \sim N(0, \sigma^2)$ denotes the random error of *i*-th student.

Correlations were expressed using Pearson's r, and effect sizes were classified according to Cohen (1988) as small (~ .1), medium (~ .3), and high (~ .5). In one case, we also used the two-sample t-test and explained the differences using Cohen's d. The effect sizes were classified as small (~ .2), medium (~ .5) and large (~ .8).

4. Results

Table 2 shows the raw data for all experiments and Tables 3 – 6 correlations for individual experiments. As concerns validation of the MATHSE and SAAMM questions, we see (Table 2) that there are large differences between computer science (mathematics/physics) students and other students. For MATHSE, Cohen's d ranged between 1.72 – 2.57 (all differences were significant with $p < .001$); for SAAMM, Cohen's d ranged between 0.55 – 1.24 (all differences were significant with $p < .05$). Correlations between these two variables were .32 - .40, i.e., in small to medium range, suggesting the existence of a common denominator.

Table 2: Raw data for individual questions (split by participants' background: "CS" stands for background in Computer Science and/or Mathematics and/or and Physics; "Oth" stands for "Others", including psychology, new media studies and art). Means and SDs are given. The variables (Pretest, MATHSE, SAAMM, Games, Graphing, and Spatial) are described in Section 3.3

Raw data from Exp. 1 - 4												
	Pretest[a]		MATHSE[b]		SAAMM[c]		Games[d]		Graphing[e]		Spatial[f]	
	CS	Oth	CS	Oth	CS	Oth	CS	Oth	CS	Oth	CS	Oth
Exp. 1	5.18 (2.75)	5.42 (3.40)	5.28 (0.53)	2.89 (1.11)	6.50 (0.78)	5.64 (1.90)	2.00 (0.91)	1.47 (0.69)	7.23 (2.13)	6.60 (2.13)	N.A.	N.A.
Exp. 2	4.53 (3.20)	5.36 (3.17)	5.31 (0.57)	3.59 (1.26)	6.38 (1.18)	5.28 (1.89)	2.08 (1.11)	1.37 (0.53)	6.31 (2.03)	5.22 (2.13)	5.08 (1.46)	4.53 (1.93)
Exp. 3	8.78 (4.60)	3.83 (2.98)	5.06 (0.80)	2.90 (1.15)	6.17 (1.38)	4.55 (2.25)	1.67 (0.97)	1.34 (0.76)	N.A.	N.A.	N.A.	N.A.
Exp. 4	4.67 (2.69)	2.54 (2.12)	5.31 (0.63)	3.21 (1.07)	6.77 (0.44)	4.54 (2.15)	2.15 (0.90)	1.11 (0.31)	N.A.	N.A.	N.A.	N.A.

Notes:
N.A. means that this inventory was not administered in this particular experiment.
[a]Scale: 0 (minimum) to 32 (Exp. 1, 2) (maximum) or 20 (Exp. 3) or 25 (Exp. 4).
[b]Scale: 1 (very small) to 6 (very large).
[c]Scale: 1 (definitely the names and propeller types) to 7 (definitely propellers' functioning).
[d]Scale: 1 (less than 1 h a week) to 4 (more than 10 h a week).
[e]Scale: 0 (nothing) to 9 (maximum).
[f]Scale: 0 (nothing) to 7 (maximum).

Table 3: Correlation matrix for Experiment 1. Numbers in parentheses denote the number of participants entering the respective correlation. "N.A." means that at least one of the respective tests was not administered. (†$p < .10$ *$p < .05$ **$p < .01$ ***$p < .001$)

Correlation matrix for Experiment 1						
	Transfer	Pretest	MATHSE	SAAMM	Games	Graphing
Transfer	-					
Pretest	.02 (69)					
MATHSE	.37**(69)	-.02 (73)				
SAAMM	.28*(70)	-.14 (74)	.32**(74)			
Games	.39***(70)	.10 (74)	.26*(74)	.28*(75)		
Graphing	.50***(70)	.01 (69)	.26*(69)	.24*(70)	.20† (70)	
Spatial	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table 4: Correlation matrix for Experiment 2. Numbers in parentheses denote the number of participants entering the respective correlation. "N.A." means that at least one of the respective tests was not administered. (†$p < .10$ *$p < .05$ **$p < .01$ ***$p < .001$)

Correlation matrix for Experiment 2						
	Transfer	Pretest	MATHSE	SAAMM	Games	Graphing
Transfer	-					
Pretest	.24*(84)					
MATHSE	.30**(84)	-.13 (85)				
SAAMM	.40***(84)	-.03 (85)	.40***(85)			
Games	.41***(84)	.00 (85)	.24*(85)	.24*(85)		
Graphing	.43***(84)	.16 (84)	.36***(84)	.29**(84)	.26*(84)	
Spatial	.19† (83)	-.03 (83)	.16 (83)	.19† (83)	.14 (83)	.22*(83)

Table 5: Correlation matrix for Experiment 3. Numbers in parentheses denote the number of participants entering the respective correlation. "N.A." means that at least one of the respective tests was not administered. (†*p* < .10 **p* < .05 ***p* < .01 ****p* < .001)

Correlation matrix for Experiment 3						
	Transfer	Pretest	MATHSE	SAAMM	Games	Graphing
Transfer	-					
Pretest	.38***(76)					
MATHSE	.22† (76)	.60***(76)				
SAAMM	.24*(76)	.42***(76)	.38***(76)			
Games	.01 (76)	.22† (76)	.09 (76)	.15 (76)		
Graphing	N.A.	N.A.	N.A.	N.A.	N.A.	
Spatial	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table 6: Correlation matrix for Experiment 4. Numbers in parentheses denote the number of participants entering the respective correlation. "N.A." means that at least one of the respective tests was not administered. (†*p* < .10 **p* < .05 ***p* < .01 ****p* < .001)

Correlation matrix for Experiment 4						
	Transfer	Pretest	MATHSE	SAAMM	Games	Graphing
Transfer	-					
Pretest	.39*(37)					
MATHSE	.57***(41)	.43**(37)				
SAAMM	.48**(41)	.34*(37)	.40**(41)			
Games	.48**(41)	.16 (37)	.47**(41)	.37*(41)		
Graphing	N.A.	N.A.	N.A.	N.A.	N.A.	
Spatial	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Table 7 shows the main results. As concerns Experiment 1 and 2 (the complex beer brewing simulation), we see that both MATHSE and SAAMM variables are indeed correlated to test scores with small to medium effect size (Tables 3, 4); however, these correlations can be largely explained by game playing frequency and graphing skills for Experiment 1 and 2, and also by pre-test score in Experiment 2 (Table 7). The only significant MATHSE/SAAMM regression coefficient is for the SAAMM question for Experiment 2 (Table 7). Because the simulation resembles a computer game and uses graphs, this outcome is in fact not surprising. Could we find a clearer effect of math self-efficacy and self-assessed ability of acquiring mental models on learning outcomes using non-game-like computerized materials with no graphs?

In Experiment 3 (the lightning formation animation), we found a small to medium effect size relationship between test performance and MATHSE/SAAMM variables (Table 5), but these two variables are also highly correlated to the pre-test score, which turned out to be the only significant predictor of the test performance (Table 7). This finding is also not that surprising because the animation's content was related to electro-physics and the link between the math self-efficacy and prior electro-physical knowledge (and achievement) is understandable. Could we find a clear effect of math self-efficacy and self-assessed ability of acquiring mental models on test performance with an animation unrelated to mathematics?

We used such animation in Experiment 4 (the biological wastewater treatment plant animation). Now, the test performance is highly correlated to the MATHSE variable (Table 6) and this variable is the only significant predictor of the test performance (Table 7). The SAAMM—test performance correlation is also high range (Table 6) and the SAAMM standardized regression coefficient is notable (0.26; Table 7) yet non-significant. This could be due to small power of the statistical test (N = 41 for Experiment 4).

Table 7: Standardized regression coefficients for each experiment. Coefficient of determination for each model is shown in the first column. The other columns show standardized regression coefficients (β) for each variable with 95% confidence intervals (CI). "N.A." means that the variable was not used in the model. (†p < .10 *p < .05 **p < .01 ***p < .001)

Main results – regression coefficients															
		Intercept		Pretest		MATHSE		SAAMM		Games		Graphing		Spatial	
Exp.	R^2	β	CI 95%	β	CI 95%	β	CI 95%	β	CI 95%	β	CI 95%	β	CI 95%	β	CI 95%
1	0.38	-0.04	[-0.25, 0.16]	0.05	[-0.17, 0.27]	0.2†	[-0.02, 0.41]	0.08	[-0.17, 0.34]	0.25*	[0.03, 0.46]	0.38***	[0.17, 0.59]	N.A.	N.A.
2	0.39	0.00	[-0.18, 0.18]	0.22*	[0.03, 0.41]	0.09	[-0.12, 0.30]	0.23*	[0.03, 0.44]	0.27**	[0.08, 0.46]	0.22*	[0.01, 0.43]	0.05	[-0.14, 0.24]
3	0.16	0.00	[-0.22, 0.22]	0.37*	[0.08, 0.65]	-0.04	[-0.31, 0.24]	0.11	[-0.13, 0.36]	-0.08	[-0.30, 0.15]	N.A.	N.A.	N.A.	N.A.
4	0.45	0.02	[-0.25, 0.30]	0.13	[-0.19, 0.44]	0.4*	[0.03, 0.77]	0.26	[-0.05, 0.56]	0.14	[-0.21, 0.50]	N.A.	N.A.	N.A.	N.A.

5. Discussion and conclusion

In all four studies, we found a relationship (i.e., a correlation) between math self-efficacy, assessed by our single question, and test performance, and also between self-assessed ability of acquiring mental models, assessed by a single question, and test performance (Tables 3 – 6). This relationship tended to be in medium to high ranges. Despite this relationship was masked and/or mediated by other variables in all treatments, except for the non-game-like animation whose content was unrelated to mathematics/physics (Table 7), its existence is a useful practical finding. The point is that in studies with between-subject design (using interventions supposed to teach mental models acquisition, such as simulations and games), the groups should be equalized with respect to these two variables. Otherwise, one group can outperform the other not due to the intervention's features but because participants from one group were predisposed to acquire the mental model easily. The equalization of groups can be done easily because researchers can administer these two questions in pre-tests and the outcome can immediately assist them in assigning participants to groups. Alternatively, the researchers can use these two variables as covariates. (Of course, it should be also tested if these variables indeed correlate to test scores in the experiment in question.)

Our finding could have also theoretical implications, if thoroughly replicated. This implication would be that people experienced in manipulating mathematical objects in working memory may be in advantage as concerns general mental models acquisition. This ability would probably be related to increased spatial abilities of these learners (cf. Ackerman et al., 1995; Höffler, 2010).

As concerns limitations of the present study, validating the MATHSE/SAAMM questions against real mathematical tests' outcomes would be vital. Note also that in Experiment 4, we did not administer graphing test, which is a drawback from the perspective of the present study (this test was not originally planned for Experiment 4). As for the test of spatial abilities: even though we have not found the link between spatial abilities and mathematical self-efficacy (Table 4), larger tests of spatial abilities can indicate differently (cf. Ackerman et al., 1995).

There are also open issues. First, it is unknown when the influence of frequent gaming on transfer test scores is mediated by mathematical skills (due to math skills—frequent gaming relationship) and when it is causal (due to materials' game-like appearance). Second, boundary conditions of this effect must be investigated: for instance, our different study indicated that our math self-efficacy question is unrelated to test performance for high school audience. We believe that the reason is that college students (who knew that diverse students participated in the experiment) related this question to general population whereas high-school students to their class (i.e., school grade), brining substantial noise due to inter-class differences.

Considering all points together, our tentative suggestion is that researchers investigating acquisition of mental models by computerized materials (using between-subject design with quantitative measures) should consider equalizing groups with respect to participants' mathematical ability. The level of this ability can be probably indicated indirectly by our two questions on mathematical self-efficacy and self-assessed ability of acquiring mental models. In future, rigorous validation of these questions and investigation of boundary conditions would be useful.

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Digital Support of Role-Play and Simulation Games in Classroom Settings

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Abstract: In this paper we describe the development of a software tool, which could be used to enrich non-digital role-plays and simulations in educational settings. It enables the integration of video as well as audio file citation and management with further functionality like smart board and mobile device integration. The tool was originally developed for the "Marshall McLuhan Salon" (MMS) of the Canadian Embassy in Berlin to support the work of the embassy´s tour guides, who facilitate teaching of school classes and university student groups. While developing the MMS solution we saw the possibilities in using the tool in other contexts and with other didactical approaches. This paper starts by describing the pre-intervention state of the MMS and then depicts our software solution to the needs of the MMS. Following we highlight some core insights from our usability testing in the embassy, which we heeded when developing the concept for a digital support of role-play and simulation games in classroom settings. Before describing its potential application in a simulation game on the energy turnaround, we showcase the combination of the three core components to support simulation games in the classroom. The paper thus shows that our tool can be used for educational experience that closes the gap between the media rich lives of youths and the valuable method of role-play and simulation games.

Keywords: role play, simulation games, class room, shared screen, bring your own device (BYOD)

1. Introduction

Following we will highlight relevant background theory of role-plays in education, discuss the key issues of these approaches in the age of Youtube, Facebook and Twitter, and will propose an approach to close the gap between the media rich experiences of youths and the valuable educational method of role-play and simulation games.

1.1 Background

Non-digital role-plays and simulation games are a very well known and valuable approach. They allow for active (Bonwell & Eisen, 1991; Meyer, 2010:367) and experience-based learning (Dewey, 1938) in primary, secondary and tertiary education. Role-plays as mimicry (Caillois, 2001:21) allow the temporary partial or complete shedding of the self – indeed, "the pleasure lies in being or passing for another" (Caillois, 2001:21). While experiences that offer a flow state in general have the potential to enable the transcendence of the self (Csikszentmihalyi, 2008), role-plays that cross the level of parallel play – "Parallelspiel" – (Renner, 2008:111) additionally offer the opportunity of transformative learning (Mezirow, 1997). This is due to the fact that role-plays allow students to explore the point of view and actions of the embodied social, cultural, economic and political figures as well as their social interactions from a first-person view. This makes them valuable tools for opening up an understanding of both their motivations as well as modes of actions. Additionally students may explore the belief sets, values and emotions of the embodied roles. Students value this experience of role-/simulation play as an exciting method of course work full of variety (Meyer, 2010:55). Role playing in school and higher education can be roughly subdivided (Meyer, 2010:348) into forms that focus on performing in front of an audience – drama or theatre (Renner, 2008) – and those that simulate a situation or conflict to enable students to work on their values and attitudes/mindset as well as soft skills and conflict management (Meyer, 2010:349).

Political, social or business simulations fall into this category. These are generally very rule-based and require that each student takes on and enacts a predefined role – e.g. company representative or environmental activist – in a specific conflict.

1.2 The problem

In school the context of these conflicts is generally supplied by written texts (Meyer, 2010:367) – e.g. newspaper articles – while in businesses or in the military, media rich environments and setups (Iuppa & Borst, 2007) are used, too. The low adoption of media other than newspaper articles is certainly due to the high production cost of films and interactive media (Iuppa & Borst, 2007), but also has a didactical and practical dimension. Newspaper articles are accessible to the teacher and can be easily collected when relevant items are encountered in daily media routine. Once collected they can be easily copied, distributed and stored both for single or repetitive use. Additionally one main or sub goal of a simulation game execution may be the exercise of using media to inform oneself on socio-cultural, political or economic issues – which was once done primarily via newspapers (Raymond, 1998:109) and later TV, too (McCombs, 2013:41). But with the advent of the web, social media and video communities like Youtube.com, the opinion formation of adolescents – and increasingly teachers – is primarily done via these media channels. Correspondingly they should be integrated into role- and simulation-play to close the gap between the media rich experiences of youths and its counter part of educational settings.

1.3 One approach to close the gap

In this paper we describe the development of a software tool, which enables the usage of video as well as audio file citation and management with further functionality like smart board and mobile device integration, in educational settings. It thus closes the gap between the media rich experiences of youths and the valuable method of role-play and simulation games. We start by describing our work at the Canadian Embassy in Berlin that formed the foundation for the further development of our concept.

2. Canadian Embassy: Marshall McLuhan Salon

In 2013 we were approached by the Canadian Embassy in Berlin, which sought advice on how to modernize their educational exhibition in the embassy´s Marshall McLuhan Salon (MMS, 2015). After some initial workshops we proposed to not simply update the existing with recent hardware, which would be outdated in two years time again, but to integrate the old hardware into new interaction concepts. Following this, we developed a web-based application system for the multimedia information center “Marshall McLuhan Salon” in cooperation with the Canadian Embassy. It allows users to control different types of media content, mainly text and film material, via mobile devices within the technical infrastructure of up to four interactive touch displays. In addition the system offers a mobile questionnaire application that is utilized for special guided tours. Following we will describe this development in depth as it inspired us to research the usage of such a system in school settings. We highlight both the capabilities and boundaries of our solution that will be referenced in our adaption for usage in schools.

2.1 Pre-intervention state

The multimedia-based information center “Marshall McLuhan Salon” (MMS) of the Canadian Embassy presents a broad range of current information about Canada. Visitors are invited to discover a collection of hundreds of film, image and audio assets as well as approximately 1000 texts about Canadian topics including an unique archive of audio and video material with and about the Canadian media theorist Marshall McLuhan and his often discussed topics. To support the research activities for guests the Canadian Embassy of Berlin utilizes a variety of technologies within the facilities of the information center. The audio-visual media content of the MMS archive is mainly presented via four large single-touch displays arranged within in the circular-shaped main space of the Salon.

Figure 1: A group of students in the MMS with wall mounted one-touch LCDs

The previous media discovery web application running on these devices provided a menu structured by language and topics so that visitors could stepwise navigate to contents and display them on the screen. For example, a user navigated through the menu structure to the topic “Nature - Wild Life” and attained to a video link. The video could than be watched on the screen by selecting the link. A video player would open displaying the film and the controls for the playback as well as for returning to the main menu. To listen to the sound of the individual screen wireless radio headphones are utilized. In addition to the media application, further information is offered for example by an interactive web-based map application, the “Canada Explorer” employing usually one of the four main touch-screens. It contains six interactive thematic maps where general information about Canadian politics, geography, history, population, economy and popular destinations are visualized in an appealing manner.

In addition to the bigger ones, six smaller touch-screen information terminals provide the possibility to view text and film as well as listen to audio material. Furthermore three additional computer stations are available for off- and online-research utilizing an interactive link collection for further details. All interactive applications in the MMS provide their content in three languages: German, English and French. In its educational scope the MMS information center offers guided tours tailored to the specific learning goals and themes of individual school classes and student groups as well as any other interested party.

Usually a tour starts with a presentation by the tour guide followed by a research phase where the participants individually investigate specific topics and issues within the center. While the “Canada Explorer” application actually provides a quiz and two other games to challenge the guests to prove their (gained) knowledge, the main focus generally lies on group discussions moderated by the tour guide. Up until now each participant had to fill out a paper worksheet/questionnaire with up to 10 questions to retain relevant data gained while researching individually. This should primarily prepare participants to access the collected information for a contribution in the following common evaluation session. Each question of the paper worksheets contained hints for retrieving the necessary information e. g. where to find a specific video file to watch, a text to read or a topic to discover in the “Canada Explorer” application. At the end of the tour – after the discussion – a version of the paper questionnaire with the correct solution or solution proposals was handed out to the group by the tour guide. Depending on the age and the requirements of the learning group, each tour’s course and questionnaire is conceived by the MMS staff individually and can be provided in English, German or French. Since the MMS is open to the public and advertisement for Canada, the Canadian embassy is interested that an exhibition visit is an enriching positive experience for their guests. Because of the broad age range of their audience different research methods need to be supported with suitable interaction concepts and technologies. At the same time the required effort for using and maintaining the systems needs to be feasible for the staff.

Figure 2: Students and one of the authors using the Canada Explorer (interactive map)

2.2 The new MMS solution

Our work in cooperation with the Canadian Embassy focused on the following issues:

- the modernization of the research possibilities in the exhibition,

- an alternative access to the video content of the MMS archive and
- the digitalisation of the paper questionnaires for school classes, university students and other learning groups.

The initial idea for the project was to enrich the available technical infrastructure of the MMS by integrating mobile devices. Advantages arise on one hand from the usage of the already existing technical equipment and on the other hand potentials emerge by supporting visitors in their research activities with additional modern interaction possibilities. As mentioned before, the employed media application provided a hierarchical navigation to access the available information ordered by language and then by topics and subtopics. This is the reason why a specific video file or text is often accessible only on a very deep navigation level resulting in many touch actions for the user and the impossibility to change quickly to a resource in an other branch of the tree structure.

For this, we developed an interface to establish the communication between one or more mobile devices (mainly tablets) and the LCD screens. The mobile devices are used to remotely control the media content (e.g. a video file) shown on one of the LCD displays and to view meta information of the medium such as title, duration, description etc. in one of the three available languages. Within the mobile application several topics with pre-defined sets of video material from the MMS media archive including chapter definitions are available (flat hierachy). After selecting a film, one of the LCD displays can be specified as the output medium to load the video. Commands to play, pause or restart the video can be triggered for the whole film or parts of it (chapters). The currently displayed media content on a LCD screen is now controllable by several connected mobile devices. Video control commands triggered on a LCD touch screen e.g. to pause a video are not only processed by the video player of the display but find consideration within the application on the mobile devices as well.

Figure 3: Students controlling the media display on the LCD via a Blackberry pad

The other essential part of the project was the digitalization of questionnaires in form of a mobile web application for tablets (mainly Blackberry Playbook). Besides the digital replacement for the paper questionnaires the Canadian Embassy was interested to provide their MMS tour guides with an overview of the given answers as well as a question / questionnaire management system. Additionally they would like to hand out something at the end of a tour that is more individual to the participants than the standard solution sheet mentioned earlier.

Our developed solution consists of two web-based application variants: a “Moderator” app for the MMS tour guides and a “Basic” app for the participants of the tour. The range of functions within the “Moderator” app differs in comparison to the “Basic” app and include e.g. the creation, the editing, the activation and the archiving of digital questionnaires and questions in four different types (single and multiple choice, text and discussion questions). In addition, this application variant provides the functionality to switch between the questionnaire phases “questioning” and “evaluation” which will enable or disable the possibility to answer questions in the “Basic” app. During the “questioning” phase the participants can access and answer the questions within the “Basic” app. In order to assign the given answers correctly some team data (name of team, icon and participants) have to be specified at the initial start of this application. Each question is then presented with a question text, further text hints and the necessary input elements to add, edit or remove answers. Beyond that a question can contain one or more connections to the MMS media library enabling users for example to play a contextual relevant video clip directly from within the question on one of the four LCD touch screens. However, in the “evaluation” phase the questions with the given answers as well as the activated solutions are available to the participants for viewing purposes only.

In contrast the tour guides have access via their "Moderator" app to all questions of a questionnaire including the given team answers. In addition, they can select the text of a question, a given number of anonymized team answers or the prepared solutions and display these on one or all of the large LCD touch displays. When the tour guide displays the recommended solution on the large LCD screens, the "Moderator" app automatically triggers all active "Basic" apps to show the solution, too. Nonetheless the tour guide may at any time trigger this by button click in the "Moderator" app interface. The so acquired correct answers can even be added to the results of the individual students which can be exported as well as printed as a group, team or individual handout / evaluation.

Figure 4: Students taking notes via the questionnaire feature

During the "evaluation" phase the display of video clips that have been assigned to a question are controllable only from within the "Moderator" app. This limitation was thought to be necessary – primarily with younger tour attendants in mind – to avoid disturbing video playback on the screens while reviewing the questionnaire results with the entire participant group.

First tests with school classes indicated that the described solution has positive effects on the stimulation/motivation of group discussions or dialogs.

Figure 5: Evaluation phase of a tour with questionnaire displayed on the LCD touch screens

2.3 Testing

We did live usability testing with two MMS tour guides and two school classes (grade 6: 35 pupils, grade 8: 8 pupils). In these tests both applications have been used and controlled by the embassy staff as well as the pupils without any major problems. The handling of the user interface to change between the questions, to select answers or enter short texts seems to present no issues. However, during the tests it emerged that the participants are more willing to contribute in the final discussion when they prepared their answers as a team instead of individually. This became especially apparent in the test with the 8th grade class. They were in total eight pupils so that each child could have their own tablet device and they worked out their answers individually which seemed to make them more reluctant to participate in the evaluation later on.

Subsequent evaluation was done by the embassy with further school tours and brought generally positive results. In one tour group the video remote control within the questions was even successfully used without any explanation from the tour guide. However, the embassy staff also reported problems when employing the app with university student groups. The questionnaires for these guests contained mainly discussion questions. This question type was especially conceived for the usage in this group setting and offers the possibility to enter several notes that are displayed in a list style. For some reason the students of several tour groups had major difficulties entering their texts via the virtual keyboard or refused to use the digital interface at all. Rather they wrote down their notes manually on a paper note block and used the application on the tablet device only to view and control the questions and their related videos. On the reasons for this we can only speculate at this time but maybe they simply did not understand that they would receive a printed handout with their notes anyway. Nonetheless further investigation in this matter is required.

Other minor problems did occur concerning sporadic browser crashes and setting malfunctions which could be solved quickly by a browser restart or by adjusting the browser settings. But the embassy staff sees the application as a valuable tool that supports their work.

3. Adaption of the system for game-based learning settings in school

While developing and testing the solution for the MMS we recognized its potential to be used both in other contexts as well as with different didactical approaches. One combination of this is the digital support of role-play and simulation games in classroom settings. Such a scenario could adapt three key features of the developed MMS solution: remote screen control, media control and the questionnaire.

3.1 Remote screen control

The most visible component of the solution developed for the MMS is the control of the large single-touch displays via the tablets. While having primarily been conceived as a workaround to evade the expansive hardware upgrade in the embassy, this enables the usage of our system in classrooms with simple interactive whiteboards (IWB) or even plain video projector systems. Thus such systems could be truly interactive screens instead of just a means to show digital content such as animations or simple pictures and websites. This would be valuable due to the fact that although Wallace (2007, cited in Manny-Ikan et al., 2011) proposes that interactive whiteboards (IWB) enable more meaningful contact between learners and the digital content, it has been noted that such modes of interaction are primarily bound to traditional models of instruction (Smith et al., 2006) and that in classes with IWBs "is no more group work or work in pairs than in a traditional lesson" (Manny-Ikan et al., 2011). While a frontal teaching style is certainly not the evil thing that some consider(ed) it to be and one should not make the fallacy of generally advocating one social form ("Sozialform" in Meyer, 1985:136f) of teaching over others (Meyer, 1995:141), we think there is a consensus that role-play and simulation games combined with group work have a huge potential that can be further leveraged by the integration of digital content. This content needs to be collected and curated in the work groups and then displayed on IWBs or simple video projectors. The latter can be done with the remote screen control and the former via the media management feature.

3.2 Media management

As described above the solution for the "Marshall McLuhan Salon" (MMS) of the Canadian Embassy, contains the feature that enables users to control displayed videos. These might be played, paused and restarted. Additional to these base features of media player functionality, it is possible to jump to specific sections of a video and play only the specified parts. Thus it is reasonably simple to use this system in combination with the remote screen control as a kind of video citation/quotation for presentations of students in classroom settings. This is valuable in itself as it has been found that preparing presentations trains students 21st century skill "digital tool usage" (Manny-Ikan et al., 2011). Compared to available presentation software – like MS PowerPoint, Apple Keynote or Impress in the Apache Open Office suite – the combined usage of remote screen control and media control allows for truly interactive participatory presentations that need neither be structured, combined and fixed beforehand nor require the repeated switching between students individual presentations. Which is extremely important due to the fact that both of the latter alternatives would clearly make a lively, and to a certain degree spontaneous, role-play session impossible as well as disrupt any debate in a simulation game. In contrast to this, our solution enables students to choose which media to display just in time. The only thing still needed to make this feasible is a feature that enables students to prepare media snippets that could be used e.g. in a debate beforehand, collect these in a well arranged way so that at a certain point in the discussion the most appropriate video snippet can be send to the remote screen and controlled by media management. For this we will tweak the above described questionnaire feature.

3.3 Questionnaire

The questionnaire feature in our MMS solution is not only a digital version of the previously used paper worksheets. Due to the fact that we added the possibility to attach a given number of videos as well as start and end timestamps for these to each question it can be used as preparation centre in group work that facilitates the discussion phase. The students could then – just in time – select one of the prepared snippets, send it to the remote screen and play it using media management. For example to either support a claim of their own group or to counter an argument made by an opposing group in a debate. Currently the questionnaire feature supports a single questionnaire being active for all students, so that each student or student group receives the same questions. This enables the teacher to guide the students to find answers or thesis to these and to support their argument with corresponding media quotes. Additionally teachers can create different questionnaires and share each of these with only one individual group so that questions might be posed that use e.g. a language style corresponding to the groups role in the play/game or that focus on views of the role(s) – leaving them potentially unprepared for arguments of the other groups.

In both use cases the teacher strongly pre-structures the work of the groups and the potential outcomes. While this might be a valuable approach for classes that are inexperienced with either group work – here strong structuring is a general recommendation (Meyer, 2010:264f) – or our proposed solution, this might not always be the teacher's intention. To create a third more open approach would be to enable student groups to create their own questionnaires, so that the feature could be used as general preparation centre combining notes (formerly known as questions) and media content. Additionally the reduced structuring by and thus influence of the teacher might be of interest in case the emancipatory potential of role-plays – as of any educational method (Meyer, 1995:97f) – is the primary reason for the administration of the role-play or simulation game.

3.4 A potential use case

A common goal of role-plays and especially simulation games in schools is the showcasing of social conflicts and consensus building that enables students to appropriate social-economic reality (Meyer, 1980:358). Such games allow students inter alia to gain a deeper understanding of roles and the circumstances that produced these as well as learning new behavioural and cognitive patterns by the constructive and creative enactment of specific roles (Meyer, 2010:362).

One public example for such a simulation game is the energy turnaround role-play published by the Bavarian Office for the Environment (BLfU, 2013). It describes a scenario in which a wind park is planned to be built between two villages by a power supplier. The play features a number of roles – such as: representatives of the citizens' action committee, power supplier, landowners, German Society for Nature Conservation, mayors, etc – that have different and partially competing interests.

The basic version of the play is designed for a 90 minutes block lecture and should follow the subsequently described order. First, the teacher initiates an introduction that collects and extends the students' knowledge on the energy turnaround (approx. 20-30 minutes). Following this, students are randomly separated into groups with two students each and all remaining ones fill the active observer group. The introduction section could also be used to introduce our tool. The teacher could showcase some media content and describe her usage of our solution along the way. Additionally our tool could be conveniently used to facilitate the randomized assignment of students into groups, which would be way faster than manually collecting slips of paper with name tags on.

Each group then prepares for the debate by collecting and discussing arguments (10 minutes). With our tool, each group owns a tablet device that enables them via the questionnaire to collect arguments and ideas as text and attach media content that can be used to support these. The media might be provisioned by the school as done in the MMS solution of the Canadian Embassy or referred directly from the Internet via a given URL or be created and uploaded by students. Although the latter would require a feature that currently has not been implemented and thus would need some extra development and testing. While in the original lesson plan this phase is scheduled with the duration of only some 10 minutes, using media requires tasks like browsing for, viewing, debating and curating content and thus would very probably not fit into this timeslot. To cater for this, one could choose the extended version of the simulation game that spans lessons on two days, with a preparation phase at home, which would then integrate the flipped classroom (Tucker, 2012) or even project based learning (Blumenfeld et al., 1991) concept. Another option would be to reduce the general introduction from 25-30 to some 10-15 minutes, so that students would prepare primarily through the group work phase instead of via a teacher centred approach.

Subsequent to the preparation phase, the actual role-play starts in which students debate whether the wind park should be built and the observer group witnesses the development and takes notes that should support the following reflexion phase (20-25 minutes). With our adapted MMS solution students could easily display pictures, videos (e.g. ASC, 2015) or sound files on the interactive whiteboard or video projector to support their view or counter arguments of the other groups.

Last but not least the intervention closes with a reflexion and evaluation phase, which is interestingly described the least by the BLfU (2013) game description and does not mention an approximated duration. This phase is heavily dependent on the observer group that should have taken notes of their observations. With our tool the teacher could prepare an observation questionnaire that supports the observers in taking notes. Again this approach would be strongly pre-structured by the teacher. A contrasting approach would be to enable the observer group to create their own questionnaire, which firstly would require them to learn about debates and their rules as well as anticipate the flow of the role-play. Secondly it would give them something useful to do in the preparation phase. Indeed, it would be interesting to enable the observers to create multiple questionnaires so that subgroups could focus either on different actors/stakeholders (power supplier, community initiative, ...) or on different aspects (communication patterns, mirroring, …) of the role-play. This could additionally reduce social loafing – the phenomena that individuals perform less in groups (for a literature review see: Simms & Nichols, 2014) – due to the fact that in small groups, individual performance is more visible than in big ones. The observers could even film the role-play, upload their movies/pictures and attach these to the relevant notes with start and end-time to support their observations.

A further advantage of our tool is the above-described feature of enriching the results of the individual questionnaires by the tour guide (here the teacher), so that she could make certain that relevant learning goals are not overlooked. For securing the findings of the whole simulation game, the questionnaires could be printed out, which would probably result in a better documentation of results than generally achieved with simulation games and role-play. Nonetheless this would certainly decrease the value of the questionnaires due to fact that the media content would mostly be not printable. Thus an electronic version that can be accessed later on would be of interest, so that students can may use it to prepare for tests or other teachers could use it in other subjects, e.g. when focusing on media literacy.

4. Discussion and future work

In this paper we described our software solution to the requirements of the Marshall McLuhan Salon of the Canadian Embassy and its potential application to digitally support role-play and simulation games in schools. The key features of our solution – remote screen control, media management and questionnaire system – fit well the needs of an intervention that closes the gap between the media rich experiences of youths and the valuable method of role-play and simulation games. Obviously integrating technology into simulation games and role-play is not without risk. Some of these can be tackled by the software solution itself. The usage of the mobile device for example might disrupt the flow of a play session if students use it to entertain themselves. This can be countered by a kiosk mode that prohibits leaving the app and by restricting allowed web spaces. Nonetheless a trade off must be found. On the one hand the more restricted such an environment is the better it can be controlled. On the other, the more restricted the less it actually enables students to explore media channels and use these to enrich the experience of all participants. First discussions with teachers have underlined the potential of our solution to support role-play and simulations in schools. Additionally further ideas have been proposed. A physics teacher, for example, would love to use our system to support his students learning with experiments, so that these could use the questionnaire as a digital protocol. Into this digital worksheet students could note their observations and results. Additionally they could use their smart phones to take pictures and record movies while preparing and executing their experiments. These should then be attached to the questionnaire and displayed on the video projector to summarize and recapitulate the learning goals. But even this concept could be framed as a role-play in which students need to play being a physicist to solve a mystery. Thus students would learn not only facts and procedures but could additionally adopt this seemingly foreign point of view to enable transformative (Mezirow, 1997) and epistemic (Shaffer, 2012) learning. In the future we plan to test our tool in varying contexts, but with a special focus on digitally supporting game- and play-based learning approaches in schools.

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An Empirical Evaluation of a Serious Simulation Game Architecture for Automatic Adaptation

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Abstract: This paper presents an architecture designed for serious simulation games to automatically generate game scenarios adapted to player's level and knowledge. We detail two central modules of the architecture: (1) the player model and (2) the adaptation module. The player model estimates the current knowledge of the player using a Bayesian Network (BN). The evidence variables in the BN are assigned through the observation of player's actions and the current state of the simulation. Considering the estimated player's knowledge and skills, the adaptation module uses automated planning algorithms to dynamically adjust the parameters of the simulation, in order to generate scenarios that will be well suited to improve player's knowledge and skills. We implemented our proposed game architecture in a simulation serious game named Game of Homes. The purpose of this game is to teach the basis of real estate. The player is a virtual real estate broker in a city who has to seek for brokerage contracts, estimate the value of houses, fix asked prices, perform visits, and close the deals. The player competes with other brokers driven by artificial intelligence (AI). We conducted a pilot experiment with human participants (N=10) to validate our architecture in Game of Homes. On day 1, participants were asked to take a pre-test about real estate skills taught in our game. On day 2, participants played Game of Homes for approximately 90 minutes and then filled up a motivation questionnaire. On day 3, participants took a post-test. Preliminary results show that in addition to induce strong motivation among the players, Game of Homes significantly improved real estate skills between pre-tests and post-tests. Results suggest that our serious game architecture allows (a) to induce learning process by providing content adapted to the player progression and (b) to keep the player motivated and interested during the game by adapting the challenge and providing new content.

Keywords: player model, game adaptation, game scenarios, serious simulation game, assessment in games-based learning

1. Introduction

Serious games can be defined as computer-based learning environments, which are built on the model of video games. There are numerous kinds of serious games, as there are for video games. This paper focuses on serious *simulation* games. Simulations allow the creation of real-world scenarios in which the player can experience a variety of situations, apply acquired knowledge to many new contexts, and use different strategies to achieve goals (Gredler, 2004). Furthermore, in game simulations, "consequences for one's actions occur in the form of other participant's actions or changes in (or effects on) the complex problem or task the student is managing", and this happens in real time (Gredler, 2004, p. 574). We believe that simulation games are appropriate to develop expertise in a domain by generating realistic real-world scenario in which gamers are cognitively as well as motivationally engaged at a deep level.

Maintaining motivation is essential in both gaming and learning (Mayer, 2011). A bored player can easily keep doing irrelevant actions or even worse, he may give up the game (Baker et al, 2010). Moreover, in many video games and serious games, the player evolves through scenarios including the same elements with the same features, which become rapidly understandable for him. He is then more likely to "game the game" (Baker et al, 2006). A simulation should provide unique scenarios including elements with particular features. Furthermore, behaviors of Non-Playable Characters (NPC) in the simulation could always not only be new to the player, but also challenge him (Beaudry et al, 2010). Simulations allow novelty of scenarios in serious games that should arouse curiosity, motivation and a feeling of control.

Many video games and serious games are based on scripted scenarios, in which the progression of the story and levels are predefined (Schell, 2008). This approach is certainly easier to code and provides control of the learning process in the game by designers, as the game progression is made to fit the majority of learners. However, it can also be a limitation, because it does not take into account the variety of learners, who have different prior knowledge in the domain of expertise, and different learning styles, in both quality and speed (Lopes and Bidarra, 2011). Serious games aim to teach specific content to each player as well as to entertain him, in order to improve his learning by keeping him interested in the game. To do so, they need to fit each player characteristics, by providing more difficult learning contexts to expert players to keep them interested, or by providing easier learning contexts to beginner players to prevent them to give up the game. Moreover, in case of complex domains of expertise, it is often impossible or too long to predict all events that could occur. Game scenario adaptation is an important feature to improve the gaming experience as well as the learning process. Adaptation in serious games should provide a better and a faster way to learn among each player.

Adaptation in video games and serious games was proposed by some authors who mainly focused on challenged adaptation in games (Lopes and Bidarra, 2011; Beaudry et al, 2010). Others focused on adaptation of narrative scenarios in serious games (Li and Riedl, 2010), and adaptation of pedagogical scenario in serious games (Niehaus and Riedl, 2009). Very few of these study proposed, in addition to a model or an architecture of adaptation in games, an empirical evaluation of generated scenarios. This evaluation is essential to confirm the benefits of adapted pedagogical scenarios over scripted scenarios.

In this paper, we propose an architecture for serious simulation games which allows real-time generation of learning scenarios adapted to the player. We then present implementation of our architecture in a serious simulation game we designed, called Game of Homes. Finaly, we present an empirical evaluation of our architecture in Game of Homes.

2. A serious game architecture for automatic adaptation

We designed an architecture, which apply to serious simulation games and allows the generation of adapted scenarios. Similarly to simulation games, the system implemented regarding our architecture generates one unique level composing the entire game session. Therefore, the system does not have to recreate a complete new world each time a new concept has to be taught. Our architecture allows the game system to modify the evolution of the simulation and thus creates new situations that will change the way of playing. This dynamic evolution of the simulation world represents the automatic generation of game scenarios to teach and train the player. Figure 1 shows the overall architecture for automatic adaptation, which is mainly composed by the player model and the adaptation module.

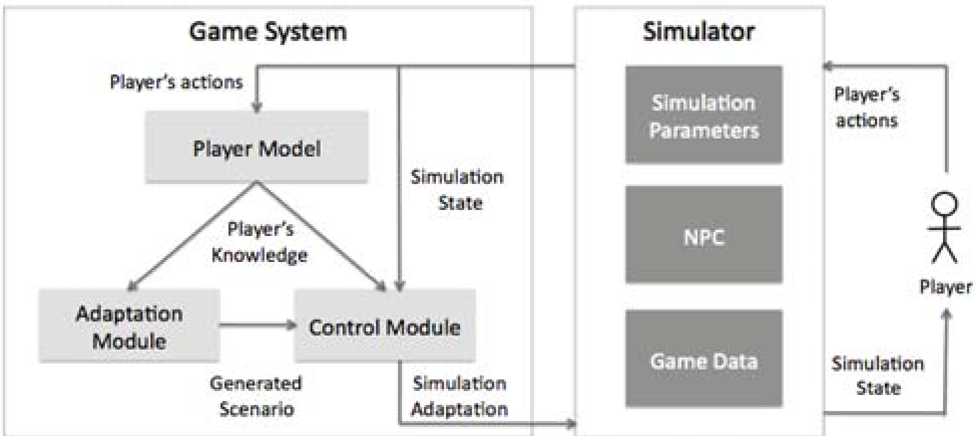

Figure 1: Our serious simulation game architecture

2.1 The player model

The player model represents the player's knowledge about the game and the domain of expertise to be learned. Its role is to estimate in real time the current knowledge of the player. When playing a serious game, there are two kinds of knowledge: the knowledge about gameplay mechanisms and the knowledge about the domain of expertise. In order to assess the knowledge about gameplay, which is easily assessable by the game, the game system observes player's actions in the game. If he performs well, we can easily deduce that the player understands how the game works.

Estimating the knowledge about the domain of expertise is more complex, because we cannot directly observe the knowledge state of the player. So it is not possible to directly deduce if the player has learned the content to be learned only by checking game actions. To estimate this kind of knowledge, the player model is using a Bayesian Network (BN). With the BN, the game system is able to infer a belief about the player's knowledge, estimates players' level in the game, and deduces possible mistakes made by the players, by combining player's actions with other game elements like player's statistics or prior encountered game situations. It provides the probability that the player has acquired a specific knowledge by inferring an update level and state of knowledge among players. Figure 2 shows a generic model of the BN in our architecture.

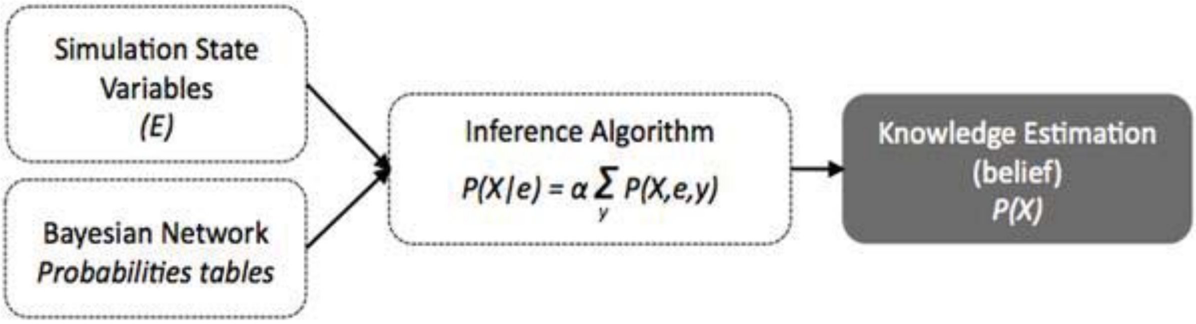

Figure 2: Role of the Bayesian Network (BN) in our architecture

The design of the BN needs a previous work of modelisation of the domain of expertise, in order to extract relevant knowledge to acquire from the domain of expertise. As every domain of expertise contains many complex skills, it is important to sparingly choose the skills to implement in the game. The more skills are chosen, the more complex the BN will be. Once the skills are chosen, we suggest to intuitively assign probabilities for each skill according to specific actions in the game (Probabilities tables). These probabilities can then be adjusted while testing the game.

2.2 The adaptation module

The adaptation module adapts game contents in order to improve the player's learning and to keep him motivated. Game contents are represented by the simulation as such, more specifically by simulation parameters, NPCs and game data.

The adaptation module decides what is the best long-term strategy to choose to both speed up and enhance the learning process. AI planning enables the selection of a sequence of actions or situations – also called plan – to achieve a goal. Every action has preconditions (needed to execute an action) and effects (produced by the action). In our architecture, planning consists on discovering the best sequence of in-game situations knowing the current player's knowledge state, in order to achieve better and faster learning of the domain of expertise. This sequence of in-game situations represents the game scenario, which represents the pedagogical scenario as well. The adaptation module decides which skills the player first needs to learn, and how to optimize the learning progression in the game. The planning process is represented as such in the adaptation module:

- states: player's knowledge estimation;
- actions: in-game situations which include a pedagogical goal to achieve (previously designed);
- actions preconditions: prior knowledge needed to achieve the situation;
- actions effects: supposed impacts on the player's learning.

Each planned scenario generated by the adaptation module is composed by these elements. It is important to note that in-game situations or actions are not predetermined as this point; their values will be fixed by the control module. This feature in the adaptation module allows more flexibility in scenario generation and guarantees generation of a unique scenario every time. We suggest to present a default scenario to the player in order to initialize the estimation of the player's knowledge. At a certain point in the game, the adaptation module generates a pedagogical plan according to this preliminary evaluation.

2.3 The control module

The role of the control module is to execute the plan generated by the adaptation module. When preconditions of the next plan action are satisfied, the adaptation module changes game contents according to the player's knowledge level. The control module then modifies in real time the simulation parameters in order to present new situations to the player, to guarantee the stability of these situations, to change NPCs' behaviors, and to provide help to players in need. If the preconditions are not validated, the control module asks the adaptation module to generate a new plan more adapted to the player's current knowledge state.

Our architecture includes in the simulation the presence of NPCs, which play the same role as the player and therefore act as direct opponents. We argue that the presence of opponents in serious simulation games guarantees challenge for players and is important to keep their motivation high. The control module can modify NPCs' behaviors according to the player's current level of expertise, which can be for example aggressive for expert players, assuring a fair challenge for them.

At last, the control module consults the adaptation module in order to identify the player's mistakes in the game. According to these mistakes, the control module commands the display of help messages to the player.

Our architecture includes two kinds of help messages:

- help about gameplay, or how to play the game;
- help about knowledge, or what knowledge to have to succeed in the game.

This adaptation allows the game system to efficiently adapt the game on the entertainment part or the learning part. The game environment renews itself and therefore engages the player and keeps him motivated. Moreover, we are also able to create very specific educational situations to evaluate players' knowledge.

3. Game of Homes

To validate our architecture, we developed the serious simulation game named Game of Homes. This game aims to teach the basics of real estate transactions. These basics include, among other skills, how to choose a brokerage contract, how to evaluate the price of a property, and the different steps of a sale process. The game takes the form of a virtual world simulation; it is not divided into different game levels as it consists of a single level. Figure 3 shows the graphical interface of Game of Homes.

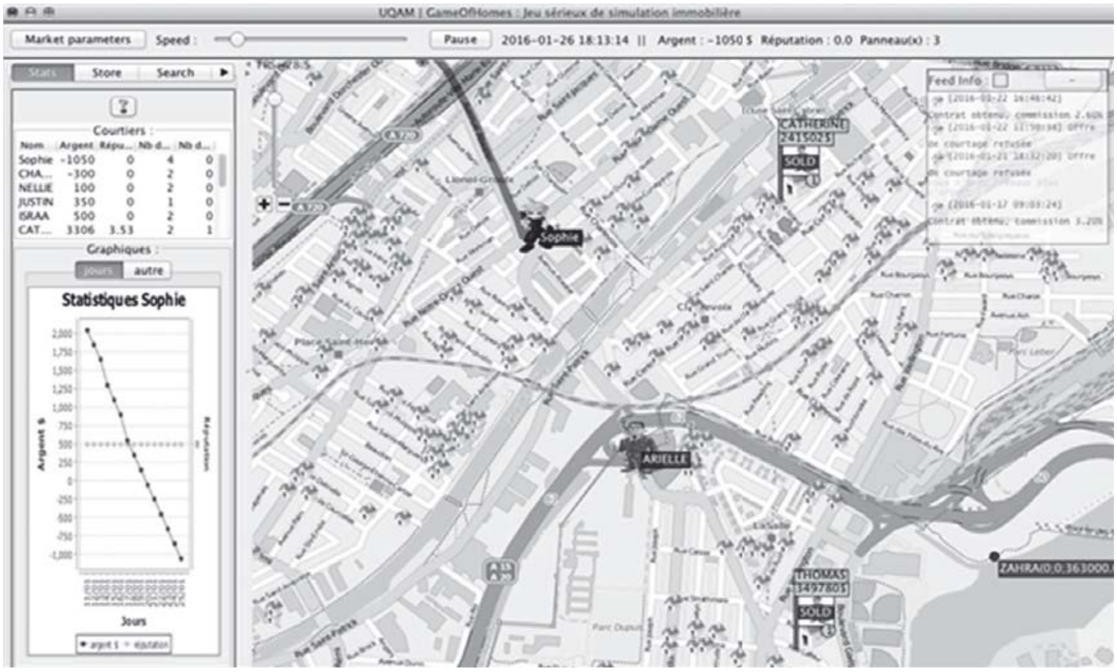

Figure 3: Screenshot of Game of Homes

In the game, the player plays the role of a real estate broker whose goal is to become the best broker in a given city, represented in a city map format. To accomplish this goal, he needs to earn as much money as possible and keep a good reputation. He can move his avatar on the map by double-clicking on the desired location. The game focuses on the selling part of real estate transactions. In the game, the player offers his services to support homeowners in selling their property. He negotiates with homeowners to get a brokerage contract, assesses the property value, and manages the sale by carrying out advertising, giving house tours to potential buyers, adjusting the selling price, and finally negotiating with buyers and recommending offers to the seller. When the house is finally sold, the broker earns an amount of money equals to the sale price multiplied by the commission rate. His reputation level is also adjusted depending on how he performed. During each activity, the gameplay allows the player some flexibility: for example, he can choose to fix the selling price higher if he believes he can sell to a higher price. Hence, the player can execute various strategies all along the game, and appreciate the outcomes of his actions.

To make the game more realistic and improve learning, the simulated environment is based on real data. The game takes place in real cities represented by maps that are imported from the OpenStreetMap project. The houses characteristics appearing in the game are derived from real public houses listings. We try to provide an environment close to reality as much as possible to allow the player to learn more about the selected city and its market reality (for example, which sectors cost more and which ones are cheaper). However, the virtual environment is not just a copy of a real city market. The environment evolves and each game is unique: for example, the features of properties are never the same, neither are the owner's requirements or the buyers' needs. This allows us to provide a large variety of scenarios, which correspond to in-game dynamic changing situations of this virtual environment.

To make the game even more challenging, the player is not the only real estate broker in the game. There are NPCs, which represent other brokers sharing the same goal as the player, and therefore act as direct competitors. In addition to competing against other brokers controlled by the game, the player needs to interact with other artificial agents. There are therefore three types of artificial agents in the game: sellers, buyers and brokers. The rules of each type of agent are inspired from observable behaviors from real-world expert brokers. To make their decisions realistic and unpredictable for the human player, a few rules integrate random decisions.

3.1 The player model in Game of Homes

Before conceiving the player model, we collected relevant documents about real estate transactions, which include professional websites, real estate websites, regulation texts, government websites, etc. The resulting model focuses on procedures which determine skills to be developed in the game, concepts and their definition needed to apply skills, principles which determine strategies to be acquired, and facts which determine examples presented in the serious simulation game.

Figure 4 presents the Bayesian Network (BN) implemented in Game of Homes. We choose to focus on two main skills: (1) Obtaining relevant brokerage contracts, and (2) Estimate the selling price. The BN estimates the probabilities that the player acquires them. Because of the non-observable characteristics of these skills, the BN needs to use evidence variables, which can be either players' actions or simulation states (or both), to Estimate these skills. We build probabilities tables for each skill.

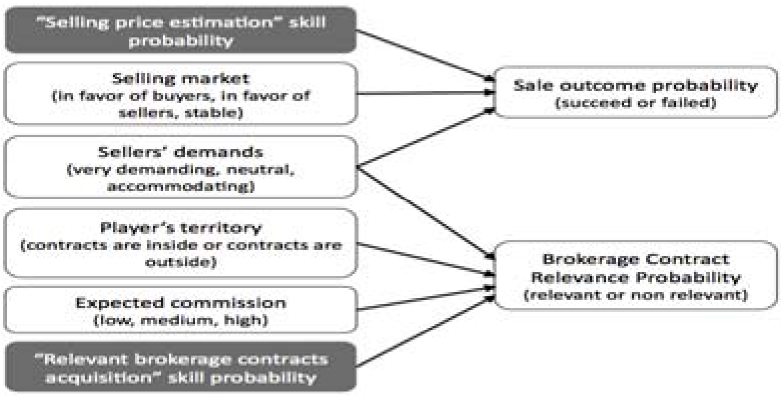

Figure 4: The Bayesian Network in Game of Homes with estimated skills (grey rectangles) and evidence variables (white rectangles)

The BN compares each player's outcome action to the probability of action in the game to success (outcome of the sale property or relevance of the brokerage contract). This probability depends on the simulation parameters (selling market, sellers' demands, player's territory, expected commission) and the player's knowledge related to this action. By using the inference principle, the BN is able to determine the current player's knowledge. For example, if a player concludes successfully two sales properties (Sale1, Sale2) and failed one other (Sale3), the

BN calculates the probability that the player knows how to estimate a selling price (called Skill1 here) (P(Skill1)) following this formula:

$P(Skill1|Sale1,Sale2,\neg Sale3) = \alpha\, P(Sale1|Skill1)\, P(Sale2|Skill1)\, P(\neg Sale3|Skill1)$
where α *is a normalized factor.*

The set of probabilities calculated by the BN are used by the adaptation module to decide the sequence of scenario best fitted the player's current knowledge.

3.2 The adaptation module in Game of Homes

We implemented the decision module with generic game high-level actions or scenarios that the control module has to specify. Eight different game scenarios can be planned by the decision module: two scenarios which aim to teach the basics of the two skills "Obtaining relevant brokerage contracts", and "Estimate the selling price", two scenarios which aim to develop these skills at the advanced level, two scenarios which aim to develop these skills at the expert level, and two scenarios including these two skills, one validating the understanding of the selling process and the management of several contracts, the other one testing if the player manages the two skills in crisis situations. This structure allows the adaptation module to target skills that need to be learned or improved among the players. The decision module can then generate a personalized pedagogical plan adapted to his knowledge level and his motivation level.

As shown on Figure 1, the simulation content in our architecture is represented by the simulation parameters, the NPCs and game data. All these elements can be adapted by the adaptation module:

- *Simulation parameters*: Modifying simulation parameters consists in changing how the player acts in the game (forcing him to take risks, leaving him the opportunity to be greedy). As an example of adaptation, the market can be changed, which will change the strategy to adapt to progress in the game, or the global parameters can be modified (how many different contracts brokers can have simultaneously, if there are special extra charges on sales, etc.). Although the actions of the game remain the same, the way to do them will differ.
- *NPC*: Changing the behavior of NPC mainly varies the challenge. It allows the control module to adapt the global difficulty in the game to the player level. For example, it can make the brokers more competitive or conversely weaker to get new contracts. It can also make buyers more discerning, sellers greedier, etc. The entertaining goal for the player is to become the best broker of the city, and these changes help the game to make this goal neither too easy nor too difficult to achieve in order to maintain the challenge as the player progresses.
- *Game data*: Changing the game data renews in-game situations. It allows the control module to create unique situations each time the player plays. For example, the game can change which houses are on the map, houses characteristics (according to the reality), in which city or part of the city the player plays, etc. In addition to renewing the game and making each game different, it also allows evaluation of the player on specific cases, which is an advantage for the teaching part.

4. Empirical evaluation

We conducted a pilot experiment to empirically evaluate our serious simulation game architecture. We mainly want to verify that (1) players learned about real estate after playing Game of Homes, and (2) players felt challenged and motivated while playing Game of Homes. We hypothesized that (1) global score and scores for specific skills will be higher for post-tests than pre-tests (quantitative analysis), and (2) each score composing our motivation questionnaire will be higher than 3.5 / 7.

4.1 Method

4.1.1 Participants and design

This study was conducted with 10 participants who were recruited by advertisements placed in a campus university. The participants were between 23 and 34 years old (Mean age 30; SD 3), 6 men and 4 women), and were rewarded with 20 dollars for participation. We made sure that participants were not or had not been owners, because our serious simulation game aims to teach the basics of real estate.

The study used a pre-test/treatment/post-test design. During the treatment phase, the participants were asked to play Game of Homes displayed on computers, during 90 minutes. The pre-test and post-test were designed to assess the two main skills taught in Game of Homes: (1) Obtaining relevant brokerage contracts, and (2) Estimate the selling price.

4.1.2 Procedure

The study was conducted during three consecutive days. Each session took place in a regular classroom equipped with computers.

- On day 1, participants were asked to take a pre-test about the two real estate skills taught in our game. This test was administered in written form that the participant had to fill in. It took on average 64 minutes to complete the pre-test.
- On day 2, participants played Game of Homes for approximately 90 minutes and then filled up a motivation questionnaire. At the beginning of this session, instructions about how to play the game were presented by trained experimenters.
- On day 3, participants took a post-test, also about the two real estate skills taught in our game. Exercises in the post-test were in the same format that the ones in the pre-test. This test was administrated in written form that the participant had to fill in. It took on average 47 minutes to complete the post-test.

4.1.3 Measurement instruments

We chose to build our own measurement instruments for this study. As we wanted to make sure that our participants (1) learned about real estate after playing Game of Homes, and (2) felt challenged and motivated while playing Game of Homes, we conceived learning tests about real estate, as well as a motivation questionnaire adapted to our game.

Learning pre-test and post-test about real estate. We designed a pre-test and a post-test which aim to evaluate real estate skills, and more specifically about the two skills targeted in our game: (1) Obtaining relevant brokerage contracts, and (2) Estimate the selling price. The tests consist therefore of two sets of exercises. The first set proposes a city map to the participant displaying properties and their characteristics (real price, owner's estimate price, quantity of rooms, surface area, agreed commission rate). The participant is asked to choose a precise number of relevant contracts among all available contracts, while justifying their answers (open questions). The second set propose a city map to the participant displaying properties and their characteristics (price of last sale, year of last sale, quantity of rooms and surface area), and a single property with only its rooms quantity and its surface area. The participant has to estimate the selling price for this particular property, while justifying his answer (open questions). At last, additional open questions ask the participant about his strategies used to select relevant contracts and to estimate selling prices. Tests were rated as follow: a maximum of 120 points for the first set of exercises, a maximum of 45 points for the second set of exercises, and a maximum of 55 points for additional questions (total score per test: 220 points).

Motivation questionnaire. We designed a motivation questionnaire adapted to our game. Some elements of our questionnaire are based on Malone and Lepper's (1987) work on individual intrinsic motivation while playing a game. These authors described four individual motivating factors: challenge, curiosity, control and fantasy. We also chose to incorporate some relevant elements from motivational models described by Lafrenière et al (2012) and Sweetser et al (2005). At the end, our own questionnaire aims to estimate in our game the feeling of (a) *challenge*: if goals, game level, difficulty, sensation of game adaptability, sensation of pressure provide enough and fair challenge to players (28 items; e.g., "I rapidly understood what need to be done to increase the score", "I felt that the game adjusted the level difficulty to my performance", "I felt nervous while I was playing the game"); (b) *curiosity*: if the game proposes new contents arousing players' curiosity and leads players to explore the environment (10 items; e.g., "The game allowed me to explore different features"); (c) *control*: if the game allows players to make different choices, which lead to significant and meaningful outcomes (9 items; e.g., "I had the feeling that my actions had significant outcomes in the game"); (d) *feedback*: if the game provides relevant and various feedbacks, and if players take them into account (9 items; e.g., "I kept checking my score while playing the game"); (e) *focus*: if the game allows players to focus on relevant elements, and therefore avoid distraction (7 items; e.g., "The game always kept my attention high"); (f) *immersion*: if the game induces sensation of flow (feeling of losing track of time) (6 items; e.g., "I lost the track of time while playing the game");

(g) *skills and game relevance*: if players see the relevance of the game in terms of developed skills about real estate (14 items; e.g., "I had the feeling that I had developed real estate skills after playing the game"). Participants responded to the items on a 7-point rating scale (0 = "Not true at all for me"; 7 = "Completely true for me"). For some items, participants had to write down their answers in sentences.

4.2 Results

4.2.1 Quantitative analysis: skills improvement between learning pre-test and post-test about real estate

To investigate skills improvement from pre- to post-test, we ran a t-test paired analysis between pre-test and post-test for (a) global score on both tests, (b) score for the first skill "Obtaining relevant brokerage contracts", (c) score for the second skill "Estimate the selling price" and (d) score for strategies about these skills. This t-test paired analysis revealed that (a) participants performed globally better on post-test ($t(9) = -3.75$, $p < .05$) than on pre-test; (b) participants performed better on post-test for the first skill "Obtaining relevant brokerage contracts" ($t(9) = -2.6$, $p < .05$) than on pre-test; (c) there was no difference in performance between pre-tests and post-tests for the second skill "Estimate the selling price" ($t(9) = -0.92$, $p < .38$); and (d) participants performed better on post-test than on pre-test in terms of strategies ($t(9) = -5.58$, $p < .01$).

Figure 5 illustrates that participants performed globally higher in the post-test comparing to the pre-test. Furthermore, it reveals that the average increase in performance from pre- to post-test is significant for the first skill "Obtaining relevant brokerage contracts" and strategies in the game, even though there were no significant differences for the second skill "Estimate the selling price".

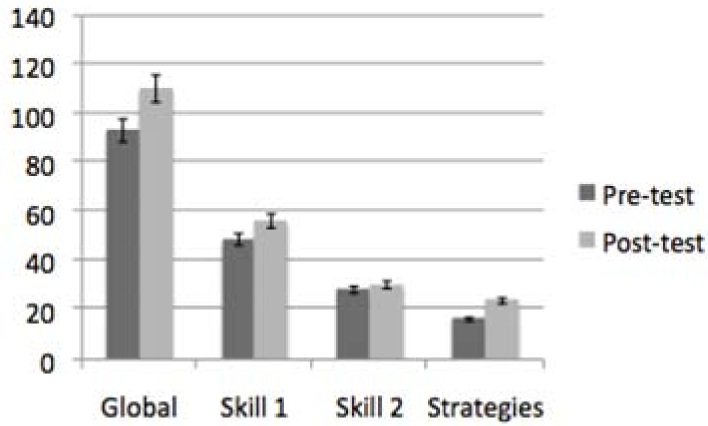

Figure 5: Differences between pre-test and post-test scores

4.2.2 Qualitative analysis: motivation induced by Game of Homes among players

We compiled results from all motivation questionnaire and present here the main qualitative results. Participants mostly felt motivated while playing Game of Homes, and more specifically expressed that: (a) the game was challenging, because they clearly understood goals in the game (mean: 5.4/7), they felt that the game adjusted difficulty to their level (mean: 4.5/7); they sensed global adaptability of the game (mean: 4.7/7) and they felt pressure while playing the game (mean: 3.97/7); (b) the game induced feeling of curiosity among players (mean: 4.39/7); (c) they sensed that they had control while playing the game (mean: 5.13/7); (d) feedback in the game was perceived has meaningful et useful by players (mean: 4.63/7); (e) they were focused while playing the game (mean: 5.55/7); (f) they had the feeling they were involved in the game (mean: 4.98/7), and even though they all played approximately for 90 minutes, it seemed to them they had played 70 minutes on average; and (g) they had developed real estate skills after playing the game (mean: 5.12/7). Figure 6 illustrates that participants felt globally motivated and challenged while playing Game of Homes.

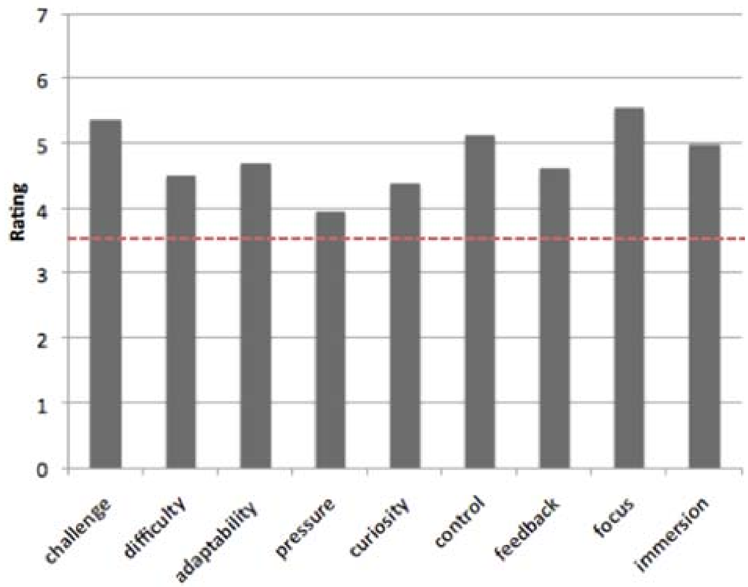

Figure 6: Sensation of motivation among players (y axis represents rating scale scores)

5. Conclusion

In this paper, we addressed the problem of adapting game content to a player in order to improving the learning process and keep the player motivated while playing a serious simulation game. Because trying to predict the majority of game situations and to propose a content adaptation in each case are time-consuming, laborious and complicated, we proposed an approach based on Bayesian network and planning algorithm. This architecture was conceived to be generalized to other serious games quite easily.

Using planning instead of scripted adaptation is both profitable for players and developers. It is easier for developers to maintain the game when it was modified and it is quicker to cover the majority of game's situations. The progression is more pleasant for the player because the content is closer to his expectations, and in the case where he replays the game, the game remains interesting and adapted to his new level and he will always meet new situations.

We conducted an experiment which 10 participants played the serious simulation game called Game of Homes implemented with our architecture. Results showed that participants globally improved their skills in real estate after playing Game of Homes. Furthermore, the serious simulation game kept players motivated and challenged. These results suggest that automatic generation of pedagogical scenarios in serious simulation game enhance learning. Indeed, players developed rapidly (during a 90 minutes game session) basics concepts of real estate domain, while enjoying it. We plan to conduct more experiments to analyze players' logs in details, in order to study different plans generated by the planning system in our architecture.

As it has been mentioned in the introduction of this paper, many games and serious games are designed with predefined scenarios, and we choose to highlight the benefits of automatically generated scenarios. As future work and in order to confirm that adapted scenarios in serious games lead to better and faster learning, we will compare players' learning in both conditions: scripted scenarios and automatically generated scenarios.

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Gamifying Activities in a Higher Education Course

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Abstract: Some professional areas requires deep practical experience in order to master an ability. In the context of programming, for instance, the learning-by-doing approach does not only help students to better understand a concept, but also facilitates the identification of problem-solving patterns. Thus, it involves the exhaustive study of variants and the replication of solutions applied to different contexts. However, the maintenance of the student practice for the entire academic period is a challenge for any teacher. In order to keep student motivation, an online e-learning environment, named Kodesh (Koding Shell), was developed as a way to provide to facilitate student practice. Some elementary gamified elements based on PBL (Points, Badges and Leaderboards) approach were introduced in the environment. These components proved to be an essential feature for the motivation of some students, but not for all of them. This teaching strategy confirmed some pitfalls, but also some potentials, which could be improved in a new version of the environment. Besides Kodesh, a set of game-based dynamics were also introduced during the lecture classes. In the classroom, students could join groups to collaborate and compete against others groups by solving challenges and puzzles. Again, this approach also showed its pitfalls and possibilities, which were useful for defining a suite of requisites for a mobile game following the "bring your own device" (BYOD) approach. This paper presents a summary of the reflexions and lessons learned from five academic semesters applying those gamification strategies in a higher education introductory programming course. The learned lessons resulted in a collection of guidelines that was used to drive the improvement of the Kodesh environment and the development of a mobile-based game named Desafio which means Challenge in Portuguese.

Keywords: e-learning, game-based learning, gamification, BYOD, programing learning

1. Introduction

One of the biggest difficulty of novice programmers is learning how to apply abstract concepts (Lahtinen et al., 2005). Thus, more than class lectures, practical experience, through a learning-by-doing approach, is essential for the student to identify problem-solving patterns. It involves the study of variants and the replication of solutions applied to different contexts. Practice is then a need, and the maintenance of the student´s practice for the entire academic year or semester is sometimes a challenge for a teacher. The maintenance of this practice concerns the student motivation, which means that the learning experience must be, if not "fascinating", at least "interesting" for all students. As long as the experience is motivating, students keep practicing problem-solving programming skills. Several authors have already related the lack of motivation to the failure rates in introductory programming courses (Gomes and Mendes, 2007; Jenkins, 2001)

In order to keep student´s motivation, an online gamified coding environment was developed. The environment, named Kodesh, was initially thought as a way to provide students the ability to practice programming at their places whenever they want. Programming problems were organized according to the contents exposed in the lectures and the students could be able to get immediate feedback of their answers as well as to check possible solutions, learning by example. That was the initial goal of the environment. Nevertheless, it was also introduced into the Kodesh environment some elementary gamified components. The gamification was based on PBL (Points, Badges and Leaderboards) approach, so often criticized (Kapp, 2012), but easy to implement for an experimental online environment. The game-based learning approach showed to be an essential feature for the motivation of some students, following findings in the literature (Erhel and Jamet, 2013; Grübel and Bez, 2006; Jabbar and Felicia, 2015), but not for all of them. The approach showed some pitfalls, but also some potentials, which could be improved in future versions of the environment. Besides the use of Kodesh, a set of game-based dynamics were also introduced during the lecture classes. In the classroom, students could join groups to collaborate and compete against others groups by solving programming challenges and puzzles. Again, this approach also showed its pitfalls and possibilities, which were useful for defining a suite of requisites for a mobile game following the "bring your own device" (BYOD) approach.

This paper presents a summary of the reflexions and lessons learned from five academic semesters applying gamification strategies through the Kodesh environment and through game-based group dynamics in an introductory programming course. The learned lessons resulted in a new version of the original environment, Kodesh, and in the development of a multi-player mobile game following the "bring your own device" (BYOD) approach. In the game, named Desafio (Challenge, in English), students in a classroom participate in a race of different activities and may drop virtual items (like bombs, freezing bolt and lightning) in order to help or disturb other students' responses.

2. Background

At the beginning of 2013, there was a deep structural change in the courses related to Information Technology (IT) at (*omitted for blind-review*). The change introduced an academic formation in two cycles: the first one giving a broad view on IT and the second one, optional, following an education on either Computer Science (CS) or Software Engineering (SE). This new model also raised the number of places at the university entrance selective process from 90 (previous year) to 265 places. Considering the rate of failure in the introductory disciplines, this significant grow forced the professors to take a new approach concerning the teaching methodology to freshman students. In order to help students, we decided for the use of a teaching tool meeting at least these five requirements:

- To have engagement mechanisms for stimulating students to practice programming, considering a game-based approach as the preferred method for engagement strategies;
- To provide micro-context problem-based learning (problems could be solved in about dozen minutes);
- To allow student to easily practice on any computer regardless the ability or permission to install compilers and IDEs (Integrated Development Environments);
- To be flexible enough to allow professors to structure the course contents following a personal agenda.
- To be useful for the entire academic period, so it could fit the needs of the teaching methodology from the very first days to the end of the period.

Prior to the mentioned structural change, some teaching tools had already been tested in previous editions of the programming course. They can be enclosed into two different categories:

- *Playful tools targeted to introducing algorithms*: these are tools aiming to present algorithm concepts, such as CodeStudio (code.org) and Scratch (Resnick et al., 2009), as well as games and puzzles, which solutions have algorithms concepts (Vahldick et al., 2014). The use of such teaching tools showed us they are suitable for the course´s first classes, when problem-solving tasks using algorithms are just presented. However, as soon as the problem starts to be complex enough to require huge visual block-building programs, students need to migrate to a real programing language and, as a consequence, to use another tool. They did not fulfill our last requirement.
- *Tools providing automatic feedback*: some tools offering automatic code testing, as those employed on programming contests (e.g. BOCA (Campos and Ferreira, 2004)), were also tried in previous course editions. However, the inconvenience found on these tools, in particular for freshmen, was the level of feedback when a solution submission was not successful. As they are normally target to programming contests, there is no additional information supporting the student learning process. Aiming to give a better support on programming learning, some tools focused on providing a worthy feedback from their automatic code testing. BOSS for instance supports code assessment by performing automatic tests for correctness and quality, checking for plagiarism, and providing an interface for marking and delivering feedback (Joy et al., 2005). Nevertheless, they did not provide game-based mechanics to promote student engagement and then did not fulfill our requirements as well.

Both categories bring however important features for learning programming. While the first one focuses on the student´s engagement, the second one gives automated assessment so the student can be aware about his/her weakness regarding the learning goals. These features are not mutually exclusives and can be found in some online tools, usually for teaching scripting languages (Javascript, Python, Ruby, Lua etc.), for instance CodeAcademy (http://www.codecademy.com). However, our introductory programming course focused on a non-script (compiled) language – C – and at the mentioned period (beginning of 2013) we did not find any tool grouping these features for this programming language. Currently, there are remarkable options for this purpose, even for compiled languages like C. An example is the URI system, which enables teachers to motivate their students in a well-structured online environment (Bez et al., 2014).

However, as we could not find an online tool fulfilling our requirements at the given period, we developed an in-house solution for our needs, named Kodesh (Koding Shell). The differential of our tool was to introduce game mechanics into the programming learning process. Kodesh fits the requirements mentioned above and provide an intuitive interface in a gamified environment. The initial version was based on an unsophisticated gamification strategy, by using the PBL pattern (Points, Badges and Leaderboards) (Kapp, 2012). This approach is often criticized, but rather simple and easy to implement. It was then suitable for prototyping the environment and learn how students would react to the new teaching method.

In order to evaluate the acceptance of the new tool and method, a poll was applied to the students through an anonymous paper-based questionnaire. The poll was composed of 9 objective questions and 3 open questions (free text) covering: 1) if it is the first contact with programming languages, 2) how easy or difficult they fell regarding the subject, 3) which kind of difficulty they usually face, 4) if they use Kodesh for practicing, 5) how they relate their academic achievement (grades) to the use of Kodesh, 6) how easy or difficult Kodesh is making the learning process, 7) if they wanted a similar tool in other disciplines, 8) if the game-based elements are motivating the use of the tool, 9) if the automatic feedback is motivating the use of the tool, and, for the open form questions: 1) the positive, and 2) the negative aspects of the tool, as well as 3) comments and suggestions.

The following data summarizes the outcomes from this survey. There were 170 respondents. 91% of them (155) answered they used Kodesh regularly to practice (11 students did not use it and 4 did not answered the question). From the users, only 12% believed they would have the same academic achievement with Kodesh, i.e. 88% judged that the tool produced an impact on his/her learning. Also from the users, 81% showed motivated by the game-based elements provided by the tool and 83% considered motivated by automatic feedback and correctness assessment. The answers about the positive and negative aspects were categorized and quantified. Among the positives aspects, game-based elements such as challenges, competition, ranking, level of experience, etc. was the most cited answer (36%), followed by automatic correction and feedback (16%) and intuitive interface (15%). Concerning the negative aspects, the most mentioned was the presence of bugs (32%), rigorous correction (29%), and unclear score system (25%).

Besides the use of Kodesh, in 2013 we also started using some game-based group dynamics in the lecture classes. The dynamics are adaptations of simple board games modified to be able to apply them in a classroom with tens of students. As an example of dynamic, groups were formed to compete against each other in a racing game board projected in the classroom whiteboard. A problem is then given and the members of each group need to discuss and to bid when they want to try an answer. The first group to bid a possible solution is required by the teacher, who ask the answer to any of its members (so, they need to share knowledge between them before bidding). Score points are given to correct answer or to other groups if the answer is invalid. Groups may also receive game items to disturb other groups in the race. When two groups get to the same place, they start a problem-solving battle for that place. These are examples of game rules used in the classroom, normally provided by the students themselves.

Both Kodesh and game-based dynamics in the classroom has been used since 2013 and the average grade results evolved from 5.6/10.0 (standard dev. 2.82) in 2012, when these techniques were not used yet, to 6.9/10.0 (standard dev. 2.56) in the last academic period (2014). However, it is not possible to affirm that the reason for this evolution is due to the new approach since there were also several external variables influencing student performances during this time (e.g. the introductory programming course was moved to the second academic period and a new preparatory course was introduced before it). Nevertheless, the new approach has been well accepted by the students and served as based for several lessons learned on gamifying learning practices, as discussed in the next section.

3. Lessons learned

The first lesson learned from the experiences presented in the previous section is that putting gamification of learning into practice is not as easy as it is supposed to be. It may be even harder than designing an (only) entertainment-oriented game since it is also supposed to motivate who does not necessarily want to "play the game" (at least with the effort we would expect to). Thus, well designed and balanced extrinsic motivation mechanics must be incorporated as one of the main presumptions of games (and gamified systems) is that playing them is a voluntary action (Huizinga, 2014). Shortly, gamified learning activities must ideally please all the students in the class. The following topics summarize the learned lessons from the choices made in order to put gamification into practice during these academic periods. Some choices showed to be inadequate for the audience while others indicated to be extremely suitable.

- In a playful environment, avoid the seriousness of grades

When Kodesh was designed, it was requested to use it as a tool supporting continuous student assessment. The idea was that the score system would reflect somehow in student grades, so they could know *a priori* how well (or not so well) they would end the course and, consequently, they could improve their grade by making bigger effort to advance in the activities. However, we had included in Kodesh the ability to check the solution of any given problem in order to allow the student to learn by example. If the student is blocked in a problem, s/he can check the answer and see how to solve it. But, in this case, s/he would not receive the points related to the activity in the score system. This conflict generated a tremendous resistance for the students to learn from the solutions provided in the system since it would reflect at their grades. Then we went back to summative assessment. The formative assessment is still in place through the automatic code validation, score system and player experience level, but this data does not reflect into the student grades. The use of Kodesh is now a voluntary action without any obligation and extrinsic motivations involving grades and official evaluations.

- Tweak the game flow

An essential rule in game design is to define a game flow in which players avoid states of boredom, for instance when the challenges are extremely easy, and anxiety, for instance when they are hardly achievable (Schell, 2014). The cost of not setting an acceptable game flow is the player demotivation. Thus, designing a flow in a gamified learning environment or in a game-based group dynamic is a challenge, particularly when there is a big heterogeneity among students. While some students may quickly finish the activities, others may remain in the first ones. This can be frustrating for both type of students. In fact, this was observed on both Kodesh and game-based dynamics, and some alternative strategies were tested in order to tweak the game flow. The easiest solution on game-based dynamics was by forming homogeneous groups in the class, i.e. the groups would have in average the same level of knowledge, even if formed by members with different levels. The problem's difficulties are chosen with the average group in mind. The strategy considered for Kodesh consists on level up the responsibilities for students who have quickly progressed in the environment. As new challenges are given to them, they keep motivated. In our case, a new challenge provided to advanced students is to create new activities. The accepted ones by the professor score points to the student (creator). Besides, any student also score points when s/he help other students to solve problems. There is a Q&A (Questions & Answers) component inspired on the reputation system of StackExchange (www.stackexchange.com) where experience points are given to the author of the best answer. This is another way to keep good students involved with the tool even when they advance faster than others do. Others strategies were also introduced, as exposed in the next section.

- In a competition, hope should never die

In games or gamified systems following some kind of competition, the goal of some players is mainly driven by the ranking position. This can lead to a potential pitfall concerning student's demotivation when they believe they can never get to top positions. Their goal seems to be unachievable consequently competing is useless. Nevertheless, competition is one of the mostly desired features in a gamified environment (the most cited positive aspect of Kodesh in the previously mentioned poll was competition: 30%) and should not be necessarily discarded from a gamified environment (Chen, 2014). At the initial version of Kodesh, students could see only the top players in two ranking systems: a ranking for the student class and a global ranking, covering all classes. While good students may focus on the global ranking, median students may target uniquely his/her own class. Since these two ranking levels were not enough to avoid the cited pitfall, new rankings systems were included in the new version. These rankings tend to favour who relatively made more effort in the previous days. There is, for instance, a ranking for the biggest score points evolution in percentage in a period of a week. Students with few score points have advantage on this ranking as they easily get more evolution percentage for the same number of solved problems. Being in top ranking leads to extra experience points, helping them to progress in the system.

- Engage students by allowing them to create their own game rules

When we started applying game-based dynamics in a classroom, we setup a simple game with a set of rules handling the game mechanics such as: when a group needs to interact, how and when points are scored, how to start, when there is a winner, etc. However, on every new game session, students proposed changes to the initial game format. They were engaged not only on the game dynamics itself but also on the game design. The possibility to define their own rules involves and motivate the students before the "main act". Nevertheless, it worth to highlight that those rules must be clear to everyone before starting the game. So, it is advised to set it up previously.

4. Created or adapted tools from the learned lessons

The lessons aforementioned served as basis to drive a set of changes in the initial Kodesh environment as well as a guideline to develop a new game, named Desafio. While the first tool (Kodesh) is mainly focused on supporting practice outside the classroom, the new game focused on bringing entertainment to the classrooms. Both tools are briefly presented in next subsections.

4.1 Improvements in the Kodesh environment

Besides the proposed changes in the previous section, a set of mechanics were incorporated in order to better balance the gamified elements of Kodesh. First, the contents of the course was structured in three sequential parts (or phases): 1) first steps, 2) beginner and 3) advanced. Each phase runs a separated contest with its own ranking and leaderboard. Thus, freshmen who did not well in a first phase can excel in a second or third phase, as they get more experienced. The rules of the score system has also been altered to allow different comparisons among students, as well as to reflect the evolution of student in a previous week (in percentage). As already mentioned, in this additional ranking system, students with few points score more than student with many points, allowing a relative reward for those who are behind. As soon as they start getting more points, their evolution rhythm tend to decrease, balancing the game system.

One of the mains concerns in the previous version of Kodesh was the reluctance of some students to check the problem solutions. Nevertheless, we wanted to stimulate this behaviour while still keeping the competitive motivation strategy. Thus, we divided the problems into two categories: the training problems and the competition problems. In the first, the student does not earn points for the ranking system. However, s/he still earn experience points to help him/her to evolve in the environment and allow the students to have a glimpse over the kind of problems they will face in the competition. The latter have time and number of submissions to accomplish. According to these remaining items when a problem is solved, the student score points and earn virtual coins. While the first one is used in the ranking system, the latter is used to buy items (explained in the next paragraph).

Another issue in the previous Kodesh version occurred when a student is blocked in a problem (also due to the student reluctance to check solution). To solve this, we set all problems in the running phase to be open. Students may choose any problem to tackle with no particular order. However, students should prepare themselves before opening competitive problems, since time and submission counting start as soon as the students open them. Another feature to prevent blocked students is the ability to buy helpful items with their virtual coins. Students are able to buy: 1) "time", when time to solve the problem is expiring, 2) "submission attempts", when they need more trials to solve a problem, 3) "partial solution", when they just want a hint on how to solve the problem, and 4) "full solution", when they give up and want to see the solution. Several strategies were set up to prevent student blockage because decision making conflicts ("should I buy this item or save it to an even harder problem?") are essential elements for any good game design (Schell, 2014).

Finally, the last important feature included in this new version relates to social aspects in the environment. As we saw groups of students been formed in social networks as a parallel way to discuss the problems, we decided to include social interaction in our environment. As a learning platform, the interaction is restraint to a "question and answers" format. Students can submit a question and others can answer to it. Who asked can chose the best answer, generating experience points to its author (used to level up). There is no restriction regarding the questions and their respective answers. Thus, students can ask for a problem solution and get the answer back. However, the experience with the previous Kodesh version showed that, due to the playful competitive nature of the environment (and with no grades interests), this is unlikely to happen.

Figure 1: Screenshot of the player dashboard at Kodesh (texts are in Portuguese)

4.2 The game Desafio

Starting from the idea of students answering activities and get instantaneous feedback, Desafio uses the concept of BYOD (Bring Your Own Device) to setup a local multiplayer game with the student mobiles or tablets in a classroom. Not restricted to activities related to programming, the game Desafio supports various kinds of interactive activities (for instance, quizzes and drag-&-drop matching), which is useful to different domains.

The game mechanics follow the dynamics tested in classroom, where students compete against each other in a racing-like game. The race is a short-duration match (ideally around 20 to 30 minutes) in which students must solve a list of problems loaded from a server into their own devices. Score points are acquired by correct answers, which ranking them in the race. The winner is the one who achieved the full expected points in less time. During the gameplay, the students may also gain items, which can be used to help or disturb classmate competitors during the match. This is useful to better balance the gameplay by proving the possibility for median students to win the match. This approach also produces more interaction among the students, since a player can have a direct influence on others' results and vice-versa, and make it more entertaining.

The items in the game can be distinguished between beneficial and harmful ones. While the beneficial items are able to help someone during the competition (a group member, for instance), the harmful ones can cause some damage to a competitor. At the moment of this writing, the items effects included in the game are listed below:

- Tip (beneficial): a tip is shown according to the current activity. For instance, in a multiple-choice question, a random wrong alternative is disabled.
- Energy (beneficial): the value of points of the current activity is increased. For instance, if the points earned with a correct answer for the activity is 15 points, it will be changed to 30 points. It is valid only for the activity viewed when the item is activated.
- Freezing Ray (harmful): the player reached by the item is not allowed to answer the current activity for some seconds (The user interface is blocked). When the effect of the item is over, the player is allowed to answer.
- Bomb (harmful): the player reached by the item is not allowed to answer the current activity definitely. Then no points are given and the next activity is shown.

As the implementation of Desafio allows that the teacher registers the activities, including their score and maximum number of attempts, some sorts of activities are available. Each one can exploit different aspects of a subject. The templates of activities currently included in the game are described as follows:

- Multiple-choice question (quiz): multiple alternatives are listed for a question. Then, the student must choose one alternative as answer. Images can be shown as complement for the question.
- Matching-column question: each option in a set of keys must be associated to an option in a set of values. An answer is generated when all options are associated.

Figure 2: Screenshots from the mobile game Desafio (texts are in Portuguese)

5. Conclusion

This paper presented a set of guidelines resulted from the experience acquired from five academic semesters applying game-based strategies an introductory programming course. The learned lessons were used as guidelines to improve an existing gamified learning environment, named Kodesh (Koding Shell), as well as to produce a multi-user mobile game named Desafio. The initial version of Kodesh is running since 2013 and helped the formation of several freshmen. Its new version and the Desafio game are in alpha-test phase and a set of beta-tests are expected to happen at the end of the current academic period. The application to end-users (students) is awaited for the beginning of the next academic period (second half of 2015). At this moment, new acceptance test will be conducted with the final users.

Although the learned lessons and tools arose from an introductory programming course, we believe they are general enough to be extended to any domain. The design principles used to set up the game balance for both tools is valuable for most of gamified learning environment. The discussed student behaviours can also be applied to typical higher education students.

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A Training Framework for the Creation of Location-Based Experiences Using a Game Authoring Environment

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Abstract: To support the development and implementation of location-based experience (LBE) as a future educational practice, we evaluate a practical approach to training and guidance, which seeks to transfer an understanding of the design and creation methods for LBEs to practitioners from multi-disciplinary backgrounds. A preliminary version of the "LBE Training Framework" is presented, facilitating consideration of constructivist pedagogical theories, training processes, visual design principles, and technical and design constraints when training end-users. The LBE Training Framework is informed by the MAGELLAN Training Framework, which utilises a constructivist paradigm to train participants on how to use the MAGELLAN Authoring Tool. To inform future iterations of the LBE Training Framework and assess the efficacy of the training methodology adopted, this paper presents a case study following a training workshop that featured the initial release of the MAGELLAN Authoring Tool. This workshop, conducted in Greece with 14 end-user participants from multi-disciplinary backgrounds, was used to gather data and evaluate the Training Process taken from the MAGELLAN Training Framework. End-user feedback and user evaluation observations were collected from the workshop participants through a series of questionnaires, one-to one interviews, and focus groups. This paper presents an analysis of the findings, and considers the delivery methods and the training content used at the workshop, informed by the MAGELLAN Training Framework which is presented in the LBE Training Framework, a training paradigm for LBE's.

Keywords: location-based experiences, location-based training, training framework, location-based games

1. Introduction

Using Location-Based Experiences (LBEs) as entertainment and educational tools has the potential ability to focus the learner at the centre of the educational experience by using rich-mediated content, geo-localised functionality and role-play. The combined use of narrative, player control and real world game pathways could seek to provide the learner with a playful yet informative space, featuring both virtual and real interactive elements in which student-led learning and reflection are nurtured and encouraged. Advances in mobile technologies further the case for developing location-based educational experiences, due to their ability to release the learners from temporal and spatial limitations, bringing about new opportunities for supporting and enhancing learning (Rogers, 2008). Mobile technologies create an opportunity for teachers to develop innovative and flexible learning scenarios beyond school walls and schedules (Liu, 2007).

To realise the potential benefits to pedagogic practice offered by mobile learning, it is essential that teachers are both willing to adopt the practice, and confident in using mobile technologies to aid learning effectively (Ozdamli and Uzunboylu, 2015). In order to aid confidence and foster perceived usefulness amongst teachers, it can be argued that there is a need for them to be taught how to use and integrate mobile technology into their subject discipline efficiently and effectively (Archambault and Crippen, 2009, p. -12)(Fiscarellia et al., 2013). Evidence has previously shown that teachers and students want to use mobile learning in education but their competence levels are not sufficient (Ozdamli and Uzunboylu, 2015)(De Pablos Pons, 2010). With experimentation into the field of m-learning, a need has emerged for more training and support to be provided, suggesting that educational practitioners should have access to suitable training in m-learning design, development, and LB technologies. Greater support and training in using m-learning may cultivate competencies and confidence in teachers wishing to use and develop Location-Based Experiences and content for educational purposes.

In order to address this need, this paper presents an early-stage framework for the use of training and guiding users on how to develop and use LBE's. Within this paper, the authors present the MAGELLAN Training Framework developed specifically to train and support users to develop location-based experiences through the use of the MAGELLAN Authoring Tool (MAT) software. The MAGELLAN Training Framework described in Section 3 is used to inform and facilitate a training session for end-users, aiming to develop their proficiency using the MAT platform presented in Section 4, then used as a case study, documented in Section 5, to inform the preliminary development of the Location-Based Experience (LBE) Training framework as described in Section 6.

2. Background

One purpose of LBE's is to extend the use of digital media to the outside world, situating users in a real rather than virtual environment, where physical structures and social protocols are pre-defined (Whyte, 2012). Outside influences such as weather, people, structures, noise and other events cannot be controlled by the player and/or the developer and can add to, or detract from, the overall experience and/or service (Reid et al., 2005). LBE's are typically reliant on using mobile technologies and location-based data, gathered through the use of location-based services and/or sensors such as a GPS module, Base ID or through local Wi-Fi connection scanning (Easton et al., 1978). As mobile technology and these capabilities continue to develop and improve, user location pin-pointing has become more accurate, accessible and real-time based, leading the way for more fields such as business, education, banking, economy and tourism to enhance user engagement of their product or service through the use of location-based experiences.

Location-based services, when considered as a subset of context-aware services, can adapt their behaviour through filtering information to one or several parameters in relation to the context of a user. These parameters include both primary context, defined by sensors; Time, Location, Identity and Activity and secondary context information, refined through combination and filtering; Personal Context, Technical Context, Spatial Context, Social Context and Physical Context in order to achieve high user profile and context data (Küpper, 2005). High-level user data gathered this way is used by organisations in various fields as an economical way of targeting and providing users and consumers with details on new or existing products or raising awareness and attractiveness of their services. For this reason, the use of personalised data and/or location awareness monitoring provides opportunities for both organisations and target users to benefit from information and/or services that may not have been available or known previously.

In light of these developments, some fields of education have begun to recognise the potential benefits of using and adapting mobile learning to suit their purposes, with a progressive rise in the number of mobile technologies and hand-held devices such as 3G, mobile phones, pocket personal computers and notebooks adopted and used for educational purposes in educational settings (Hsu et al., 2013). One such benefit of using LBE's for educational purposes is that they facilitate ubiquitous learning (Zurita and Nussbaum, 2004) and provide a natural learning environment that favours constructivism and collaboration in order to achieve new knowledge acquisition. These types of innovative learning environments can be used effectively to promote social development and communication skills that are vital for creative and collaborative learning.

There are however, certain challenges relating to teacher and student perceptions, awareness, and competencies when using location-based services for educational purposes. Studies into the literature indicate that teachers and students generally have positive perceptions of the use of technology in education. (Isikoglu and Ivrendi, 2007)(Ting, 2013) However, it has been shown that teacher competencies of using mobile-based learning can be lower than the competency of students, showing a 'meaningful difference between the m-learning adequacies of teachers and students' (Ozdamli and Uzunboylu, 2015).

Differences in competencies could foster a lack of enthusiasm in teachers to embrace location-based learning into their delivery style through fear of lack of experience, comfort or perceived usefulness of using new technologies for education. To tackle this issue, tailored training and support in the field of LBE design, development, and use should be provided and available to all educational facilitators. Through knowledge and understanding of LBE development and its technology there is a greater chance that teacher competency and acceptance of location-based learning will follow (Jones and Flannigan, 2006).

Whilst courses and training guides are available on traditional games design and development, less information is available on the subject of developing location-based experiences and games. Additionally, a considerable proportion of the games design and development training material that is readily available is heavily structured towards a technically-minded audience, and hence not necessarily appropriate for novices or the technically inexperienced. In order to move forward in this field and help foster understanding and engagement of location-based learning within practitioners of the educational community, LBE training guidelines should reflect a broader audience and assume that the participant has no previous knowledge of developing games or location-based experiences.

To address this need, presented in the following section is the MAGELLAN Training Framework that was developed to train end-users on how to develop LBE's using the MAGELLAN Authoring Tool presented in Section 4.

3. The MAGELLAN training framework

The MAGELLAN Training Framework (MTF) has been developed specifically to train end-users, i.e. location-based experience authors, to exploit and use the MAGELLAN Authoring Tool as a means to create, organise and publish location-based experiences.

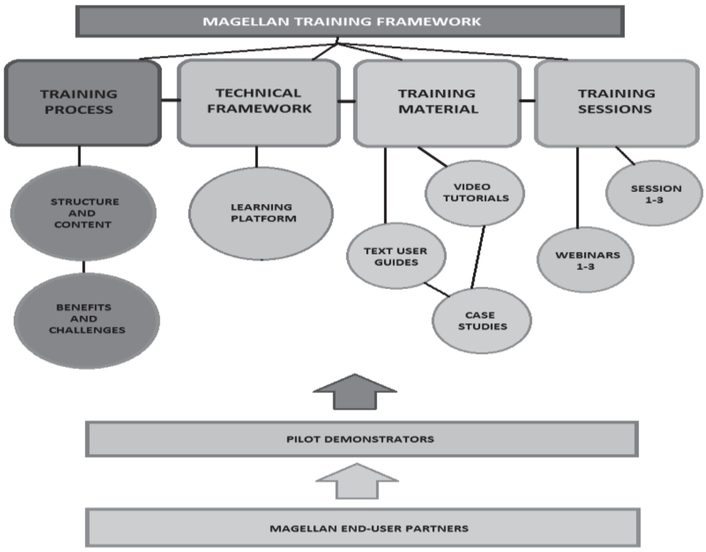

Figure 1: The MAGELLAN training framework

The MTF shown in Figure 2 presents a general training process that encompasses a suggested list of technological tools, resources and the training content necessary to achieve a comprehensive methodology for training authors to navigate through the MAGELLAN authoring platform and gain the necessary competences to create location-based games.

The objective of the MTF methodology is to create and sustain user interest in the creation of location-based games and encourage the communication of creative ideas between peers. This method looks to promote the users overall learning experience and fosters improvement of user design and development methods through an iterative process.

The MTF is split into four main components covering the Training Process, Technical Framework, Training Material and Training Sessions.

4. The MAGELLAN authoring tool

The MAGELLAN Authoring Tool (MAT), shown in Figure 1, is a games authoring platform (Balet O. et al., 2015) that has been specifically created to enable non-programmers to rapidly create and publish multiple forms of location-based experiences, involving several participants who compete or collaborate to achieve the activities and goals decided by the author. The development of collaborative experiences currently requires mastering and combining a substantial number of different technologies, reducing accessibility. This goes far beyond the development of a traditional mobile game and requires, for instance, the articulation and integration of positioning, networking, cloud-computing, interactive storytelling, VR, AR, or mobile technologies. For that purpose, it models location-based experiences as a non-linear narrative structures made of trans-modal activities delivered to the participants through their mobile devices. These activities can take multiple forms ranging from informative HTML/JS content to more advanced and interactive games making use of 3D or augmented Reality principles.

Visual authoring metaphors have been derived from this model to enable the creation of the narrative structure using building blocks (i.e. preconditions, activities) that can be linked together and visually parameterised. All edits are performed either in the scenario editor that represent the narrative structure or on the 3D map view of the geospatial playground that can include both indoor and outdoor areas.

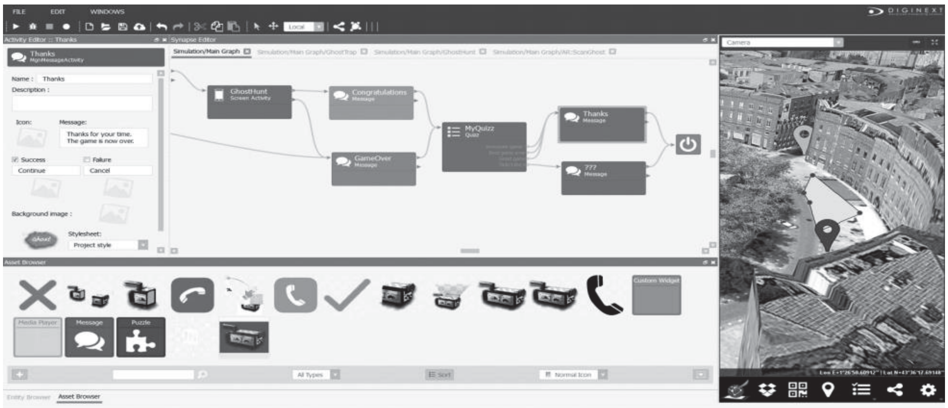

Figure 2: The MAGELLAN authoring tool

5. Case study

An end-user training workshop was held on February 4, 2015 in Athens, Greece to initiate and facilitate the training process of the alpha release of the MAGELLAN Authoring Tool (MAT). The workshop was organised to deliver hands-on experience of operating and developing location-based experiences using the MAT platform to a cohort of end-user developers involved in the MAGELLEN project. The training session, facilitator delivery, training material and the overall training methodology that was delivered at the workshop was directly informed by the MAGELLAN Training Framework.

The training session ran over one morning and one afternoon and comprised of a range of training activities that included both formal and informal training styles that had been informed by the MTF. The training session was attended by 18 participants in total of which 13 participants were end-user trainees and 5 participants were training facilitators and/or moderators.

In order to evaluate the efficacy of the training session that had been developed using the MTF methodology, a Software Training Evaluation Questionnaire (STEQ) was given to the participants to provide feedback at the end of the training. The STEQ consisted of 15 continuous scale questions and 14 open questions/comment sections in which the end-user participants could record their comments and thoughts. The questionnaire focused on providing feedback through five main measures of the training:

- Training Material – Quality
- Training Material – Content
- Training Material – Relevance
- Training – Organisation
- Training – Instructor & Teaching Method

Additionally, the STEQ provided open sections that enabled the participants to write down their feedback and comments concerning areas such as:

- Strong Points of Session
- Things to be Improved
- Recommendation of Course
- Other things to include
- Additional Comments

5.1 Quantitative data

A continuous scale, ranged 0 to 10 with 0 indicating not effective and 10 indicating very effective, was applied to collect quantitative data in the STEQ. The 15 scale based questions that are presented in Table 1 were included in the STEQ.

Table 1: Continuous scale questions from software training evaluation

	Question	Measure
Q1	How thorough and complete was the content of the video?	Content
Q2	How thorough and complete was the content of the Handbook?	Content
Q3	How clear and understandable was the content of the Video?	Content
Q4	How clear and understandable was the content of the Handbook?	Content
Q5	What was the overall quality of the Video (sound, video, images)?	Quality
Q6	What was the overall quality of the Handout (e.g., organisation, presentation, readability)?	Quality
Q7	How well was the overall training organised in terms of time (e.g., was the amount of time adequate for training?	Organisation
Q8	How relevant was the overall training in terms of helping you to understand how to use the program?	Relevance
Q9	How relevant were the prepared materials (e.g., did the materials match up to the training session?, did materials aid your learning?)	Relevance
Q10	How much did the group session aid your learning (Peer-to-Peer session)?	Relevance
Q11	How well prepared are you now to use the software on your own?	Relevance
Q12	How effective was the instructors teaching method in promoting learning (e.g., the way the instructor delivered material, content and instructions.)?	Instructor & Training Method
Q13	How effective was the instructor in terms of their effectiveness in addressing questions and concerns raised during class?	Instructor & Training Method
Q14	How important was it for you to learn how to use the software?	Relevance
Q15	To what degree do you think you have been trained to use the software to meet your needs?	Relevance

Figure 4 illustrates the mean values that from the 14 participant data entries for the 15 10-point scale questions.

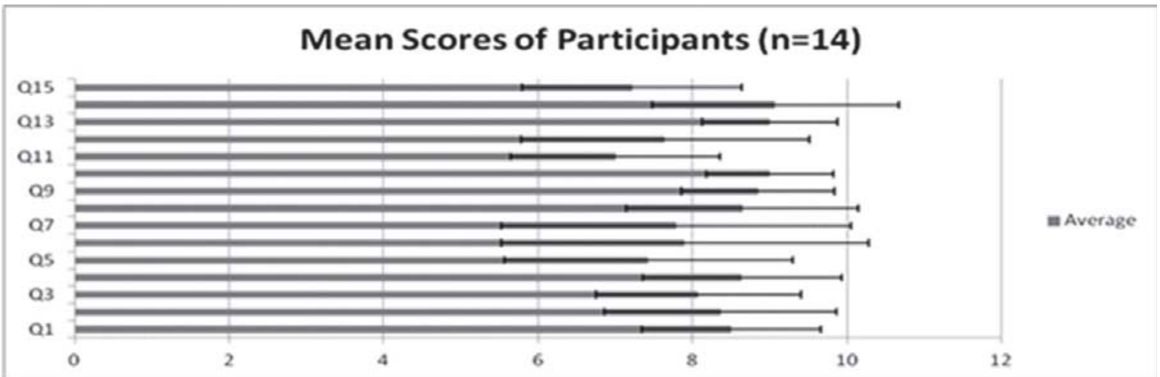

Figure 3: Mean values for scale questions

The overall mean score of 8.15 (SD=0.7, n=14) showed a positive response from participants overall, though this should be taken in the context of the limited sample and single site. There was little variance between the five topic areas (quality, content, relevance, organisation and instructor method), which could suggest participants felt the approach was effective in all these areas, but also suggests future work should focus on refining this metric to ensure data elicited from a larger sample can more strongly identify the strengths and weaknesses of the system. That the highest score was given to the question "How important was it for you to learn how to use the software" suggests an existing prior degree of perceived usefulness, which may not be reflected in a wider sample of potential end-users, given the existing limiting factors in the uptake of LBEs outlined in Section 2. Given these limitations in conclusively identifying strengths and weaknesses of the system from the quantitative data alone, the next section outlines in greater detail the qualitative findings for participants, before the refinements to the LBE training framework suggested by this data is presented in Section 6.

5.2 Qualitative data

The second section of the STEQ was developed to gather open feedback and comments on various aspects of training. The participants were instructed to think about the training session and to write their comments, including changes or improvements in the guided sections provided. 14 sections were developed for the open feedback portion of the questionnaire which are presented in Table 2.

Table 2: Open feedback sections of software training evaluation questionnaire

	Section	Measure
S1	Pace & Structure of the Training Session	Organisation
S2	Relevance of Course Content	Relevance
S3	Relevance of Prepared Materials	Relevance
S4	Group Atmosphere	Instructor & Training Method
S5	Content Meeting Expectations	Content
S6	Teaching Method	Instructor & training Method
S7	Quality of Feedback	Quality
S8	Interest in Session	Relevance
S9	Goals were Met	Content
S10	Strong Points of Session	Open
S11	Things to be Improved	Open
S12	Other things liked to have learnt	Open

Qualitative data gathered from the STEQ presented some suggestions from the participants within the 3 open discussion sections.

- Participants commented that they would have liked to have learnt how to customise aspects of game elements for use in their own games and apps.
- Participants commented that more detailed instructions or a manual could have provided more guidance in areas that were not so clear.
- Participants commented that greater instruction of the 'why' location-based experiences are useful and that game design principles were needed in the training. This referred to explanation of location-based experiences in general and overall game design principles.
- Participants commented that some guidance in technical aspects of Location-based experience development would be useful.

The open feedback section in the STEQ revealed four main areas that participants provided feedback for suggested improvements to be made for future training sessions. The four comments were split evenly into two major suggestions for material and training content development and two major suggestions for improving overall knowledge on location-based experiences.

The feedback received concerning improvements for more materials and training content highlighted the importance of ensuring a vigorous approach to developing a process in which a training action plan is set out, relevant training resources are developed and that an adequate evaluation plan is undertaken to ensure that learning objectives are being met. Following this feedback, these individual elements were developed into a separate Training Process section within the LBE Training Framework to address the importance of carrying out each of the stages for maximum support in developing a high-quality training approach.

A new stage that was introduced into the LBE Training Framework following the participant feedback for additional training material and content was the need of an End User Requirement stage placed at the beginning of the training development process. Adopting an End-User Requirements planning stage helps to assess the wants and needs of the trainees at an early stage in the training development process. Prior use of an end-user assessment process for the development of the training that took place at the Athens workshop may have led the developers to understand that participants wanted to learn more about how they could introduce their own material and assets into the Magellan Authoring Tool. To help ensure that end-user needs are addressed foremost when developing location-based experience training, the LBE Training Framework suggests that the first action in developing training should be to undertake an End-User Requirements session in which facilitators can address trainee needs.

The second major suggestion that arose from participant feedback was that not enough information was given on the background of location-based experiences and general games design principles in order to assist non-gamers/ developers in their understanding of the qualities of game based learning. Participants commented that the training given was concise in delivering the 'how' to develop a location-based experience but lacked the information regarding the 'why' they would want to. To address this, the LBE Training Framework includes a section that suggests the training process should include the key aspects of games design, location-based experience background and design and technical considerations for LBE design. The inclusion of this segment of the LBE Training Framework is used to help complete beginners and non-gaming trainees in understanding the basic principles and theory of using games and in particular location-based games to for serious purposes.

The qualitative data from the training session held at the training workshop presents a case for the future use of aspects of the MTF methodology. The data found on average that the majority of participants that experienced the training session gained some knowledge and understanding of location-based experiences and the MAT platform.

The qualitative data received from the STEQ presented in general a positive response to the training process and materials that were offered at the workshop. The two major suggestions that arose from the feedback following the use of the MAGELLAN Training Framework have been directly addressed and re-worked to be included in the first iteration of the LBE Training Framework for future training in location-based experience design.

6. The LBE training framework

Following the feedback on the training session that was informed by the MTF methodology, a new preliminary framework; the LBE Training Framework is proposed below in Figure 5.

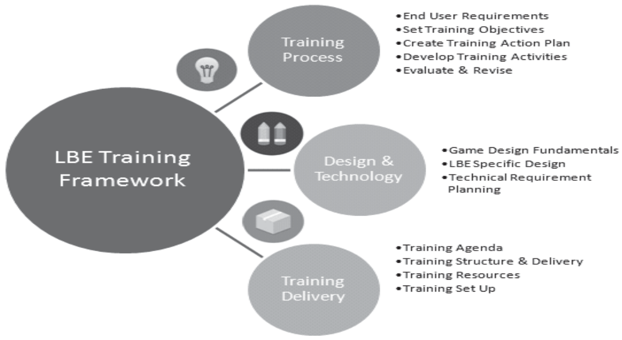

Figure 4: The LBE training framework

The LBE consists of three phases amalgamating core concepts of the MTF with feedback received from the participant training workshop.

6.1 Training process

Informed by the MTF Training Process used at the training workshop, the Training Process is split into 5 stages; End-User Requirements, Set Training Objectives, Create Training Action Plan, Develop Training Activities and Evaluate and Revise.

6.1.1 End-user requirements

End-User requirement planning helped to identify the content that was to be delivered to the participants in the training workshop. The feedback received found that adopting this approach was somewhat successful with content and relevance of training commented on as 'sufficient' and 'good for beginners'. Adopting this approach, this stage is used to define user training requirements from the offset. End-User Requirement planning is used to create a comprehensive review; understand current gaps surrounding the training problems and to ascertain ideas and feedback for user content. Accurate information can be ascertained and used to form the overall Training Process.

6.1.2 Set training objectives

During the training workshop, it was essential to have learning objectives in which the participants could work towards and feel that they were progressing in their development. Following the learning objectives that were set for the workshop; participants should have a basic knowledge in the main components of the MAT platform, the feedback indicates that all of the participants felt they had a basic knowledge of the MAT by the end of the training workshop. To follow this, this stage is used to identify achievable training objectives that are to be accomplished by the training participants over the course of the training program. The training objectives are created to correlate to any data taken from the End-User Requirements stage.

6.1.3 Create training action plan

The Action plan was used to develop the educational methods in which the training was going to be developed for the workshop. The feedback from the participants indicates that the mixed application of delivery styles focusing on a constructivist approach was received well with comments such as 'work in groups was useful' and that the training method was 'good'. A Training Action Plan is therefore proposed to be developed in accordance with the feedback from the End-User Requirements and the Training Objectives that are set. The Training Plan is used to outline any pedagogical theories and methods that are to be adopted for the training programme. Theories and methods chosen are used to structure the delivery style, material and structure of any training sessions to ensure that learning objectives and goals are likely to be met by the participants.

6.1.4 Develop training activities

Training activity planning was used to help inform the development of the training agenda and training material to be used at the workshop. Participant feedback suggests that most of the training material was found to be relevant to the training but the quality needed to be improved on. The Develop training Activities stage is proposed in which the training agenda and the training material are developed in unison with the set Objectives and the Action Plan. Within this stage, quality control of materials and resources should be addressed.

6.1.5 Evaluate and revise

The development of the STEQ was used to help evaluate the efficacy of the training given at the workshop. Adopting this approach has provided the feedback necessary to address participant and training related issues or concerns for future training purposes. The Evaluate & Revise stage is used to develop evaluation material and gather data relating directly to the training experience on issues such as, but not limited to; Quality, Delivery, Trainers/Moderators and Usefulness which is used to inform future iterations of the training program.

6.2 Design and technology

Following the qualitative feedback gathered from the participants, a Design & Technology section is used to address the training need that was raised for this area. The Design & Technology phase is split into 3 stages; Game Design Fundamentals, LBE Specific Design and Technical Requirement Planning.

6.2.1 Game design fundamentals

Within the workshop, there were several participants that were not from design or technical backgrounds. Feedback in the STEQ suggested that some initial training in basic game design principles and theories would help them understand how to develop design concepts. To address this feedback, this stage ensures basic principles are addressed so that participants who do not come from a design or technical field benefit from understanding basic game design concepts when undertaking LBE design and development.

6.2.2 LBE specific design

Following on from feedback concerning training of game design principles, participants also suggested that some LBE related design training would be useful and would answer questions as to why they might use LBE's. LBE specific design is discussed in this stage relating to issues and considerations such as but not limited to; location-based design & planning, LBE Objectives design and user safety.

6.2.3 Technical requirement planning

Within the workshop different levels of technical expertise were exhibited from the participants. Due to the variance in skill, some training material and activities may have been too novice or too advanced for the participants. Following this, the authors propose the Technical Requirement Planning stage in which software and hardware that is to be used in the training program are considered by both facilitator and participant. Facilitators prepare and familiarise themselves for using any technical based components in the training program and address possible levels of technical competencies. Participants are made aware in training of the technical elements that are to be used in training and that are needed for LBE design and development.

6.3 Training delivery

In order to deliver a successful training workshop, careful planning regarding how the training was to be delivered to the participants was required. The Training Delivery phase informs this process and is split into 4 stages; Training Agenda, Training Structure & Delivery, Training Resources and Training Set-Up.

6.3.1 Training agenda

An agenda was developed for the training workshop in which the participants would follow a specific course of training in order to achieve the set learning objectives. The feedback that was given in the STEQ regarding the Pace and Structure of the training indicated that the participants felt that the structure of the training was good however more time would have been beneficial. This stage is proposed so that adequate planning for content and timing is set aside for the entire training program that is to be delivered. The agenda should ideally be informed by Phase 1: the Training Process.

6.3.2 Training structure and delivery

Alongside the agenda, structure and delivery of the training were planned and accounted for in the planning of the training workshop. Participant feedback concerning the structure and delivery of the training delivered at the workshop found that overall it was received well. The Training Structure & Delivery stage develops theories and methods from the Training Action Plan stage to inform the training delivery style and structure of the training sessions. This helps ensure that learning objectives and goals are met at this point.

6.3.3 Training resources

Planning for the training resources to be used at the training workshop helped inform the development of the training materials, the amount of materials and how the participants would access the materials. Feedback concerning the training resources indicated that participants felt the style and content of the materials helped their learning but some additional resources such as a 'handbook' would have been beneficial. This stage uses theories and methods developed from the Training Action Plan stage to inform the development and delivery of any training materials and resources to be given to the participants.

6.3.4 Training set-up

The set-up of the training workshop was considered carefully in order to minimise any negative impact that aspects such as location, room, table arrangements etc have on the training experience of the participants. Feedback from the STEQ concerning the set-up of the workshop has indicated that whilst most participants were content with the set-up conditions, some would have liked more space on their tables or a bigger room for training purposes. To ensure these aspects are considered, the training Set-up stage is used for consideration and planning to be are given to areas such as but not limited to; location of training, room set-up, technical equipment set-up and table & seating arrangements.

7. Conclusions and further research

Presented in this paper is the first iteration of the LBE Training Framework that has been informed through the development and trial application of the MAGELLAN Training Framework at a training workshop and the subsequent participant data, qualitative and quantitative, received from the trial. Developed from the data, the LBE Training Framework presents some main areas for consideration to aid training end-users in the design and development of location-based games and experiences. Through an examination of the quantitative data it is recognised that the evaluative measures need to be refined for clearer data in future assessments of the frameworks proposed. Furthermore, more in-depth qualitative data regarding the efficacy of the individual stages proposed in the LBE Training Framework will aid assessment and future iteration developments. Future work will include further expansion of the MAGELLAN Training Framework to continue to inform the LBE Training Framework's development throughout the process of the MAGELLAN project. Furthermore, future trials that obtain facilitator based data are proposed to observe factors such as perception, usefulness and efficacy of the LBE Training Framework from a facilitator's opinion.

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The Great and the Green: Sustainable Development in Serious Games

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Abstract: Sustainable development education remains a hugely relevant and urgent pursuit across all sectors of society. In 2002, the United Nations General Assembly declared 2005-2014 the UN Decade of Education for Sustainable Development. Within the European Union, there has been a focus on establishing regulations with regard to environmental awareness and prevention solutions in European countries over the past 30 years. The U.S. Partnership for Education for Sustainable Development (USPESD) was conceived in 2003 and is dedicated to education for sustainable development in the United States. This paper puts forth the case for the use of serious games to help support this noble cause through the use of games for conventional skills and knowledge development related to sustainable development, in addition to the use of games to help promote a shift in fundamental attitudinal dimensions by constituting a form of procedural rhetoric (Bogost, 2007) based around the learner experiences of rule-governed variables related to sustainability education. This paper offers a qualitative meta-analysis of the learning computer and video games have been shown to support and goes on to focus in on the specific area of games which are aimed at fostering knowledge and skills related to sustainable development, in addition to cultivating a range of important generic metacognitive and 21st century skills. The authors map a range of such skills and learning to a spectrum of existing commercial and serious video game titles, across a wide range of game genres, including strategy games, simulation games, action games, amongst others.

Keywords: serious games, game based learning, games for change, sustainability

1. Serious games for education

Games are often touted for their potential to facilitate both formal and informal learning due to their implicit educational merits. Many game-based learning researchers, and indeed instructors, have noted the link between general game characteristics and learning. Whitton (2010) opines, "good learning activities are intrinsically challenging – but achievable – and stretch and engage the learners through gradually increasing levels of difficulty". Shaffer (2007) notes that games build situated understandings, effective social practices, powerful identities and shared values and ways of thinking. The pedagogical model and methods used within serious games environments are based on authentic constructivist approaches of promoting collaborative learning and active participation in order to build meaning.

While theory provides an extremely good basis for learning, situation or context-based experience is where authentic learning can be implemented and higher-level metacognitive activities such as planning and evaluation, and critical and creative thinking can take place and can help to facilitate the application of knowledge and skills. The movement towards this reflective and focused utilisation of knowledge and skills, as a goal of the learning process, can be seen in learning theories such as Bloom's Taxonomy (Bloom et al., 1956) and Sternberg's Developing Expertise Models (1999). The immersive nature of games are a means to offer simulated environments in which players can lose themselves for extended periods of time, of their own volition, and can facilitate learning within a generated context or situation in a way few other approaches can offer.

An additional key factor in the use of an educational game is motivation. The game environment is motivating, so that the learner repeats cycles within a game context. As noted in "Intelligence as Developing Expertise" (Sternberg, 1999; Sternberg, 1985): "Motivation drives metacognitive skills, which in turn activate learning and thinking skills, which then provide feedback to the metacognitive skills, enabling one's level of expertise to increase". This motivational aspect is an element which games can very effectively implement - a key element of which, however, is offering significant challenge(s) to the player. Flow Theory, as proposed by Mihaly Csikszentmihalyi (2002), is a useful description of this balance of challenge and motivation. Flow theory refers to a focused state of motivation, a balance between frustration and boredom. This theory claims that learners can remain motivated to facilitate effective learning when tasks are suitable enough for their skillset yet also retain a challenging element. Games, as outlined earlier, are able to facilitate this flow by offering challenge appropriate to the player's abilities and increasing the challenge as player ability increases - a concept outlined by Gee as part of his 36 learning principles in games. Peng (2004) notes that "students learn in a flow state where they are not just passive recipients of knowledge, but active learners who are in control of the learning activity and are challenged to reach a certain goal".

Indeed, the nature of games, as "play" has been identified as possessing their own innate pedagogical benefits. As identified by Vygotsky "…play creates a zone of proximal development of the child. In play a child always behaves beyond his average age, above his daily behavior; in play it is as though he were a head taller than himself."(Vygotsky, 1933). This "Zone of Proximal Development", the "gap" between what a learner can achieve independently and what they may achieve with assistance from a "more knowledgeable other", is a relatable concept to the task of "scaffolding" in game design, whereby learners are able to gain new skills and knowledge with structured, individualized, just-in-time assistance. Video games are extremely flexible in scaffolding participants' learning due to their ability to continually challenge the player to perform while avoiding the creation of unachievable goals so that players are required to operate at the outer edge of their capabilities, similar to Csikszentmihalyi's flow theory.

2. Games for sustainability education

Sustainable development is a widely accepted, though still debated, concept (Hopwood et al, 2005; Richardson, 1997; Elliott, 1994) that links environmental issues with a variety of socio-economic problems in an attempt to minimise the effects on future generations. Although the issues are evolving and of increasing concern, the definition offered in the 1987 Brundtland report remains popular - "development that meets the needs of the present without compromising the ability of future generations to meet their needs" (WCED, 1987). Sterling (2001) argues that in order to ensure sustainable development a focus should be made on education whereby a new more transformative learning approach in necessary. He notes that this approach or model should "value[], sustain[] and realise[] human potential in relation to the need to attain and sustain social, economic and ecological well being" (p22). By recognising the interdependencies between economic, social and ecological issues, researchers and educators hope to reduce the gap between value and action with regard to sustainability (Sterling, 2010). Use of the term "ecoliteracy" has grown in recent years with educators recognising the need to include more sustainability education in the curriculum and develop pupils' ecological intelligence (Goleman et al, 2012; Orr, 1992). In addition, the UNESCO Education for Sustainability report highlights that both "formal and non-formal education are indispensable to changing people's attitudes so that they have the capacity to assess and address their sustainable development concerns" (UNESCO, 2002).

Sauve (1999), described sustainability education as being similar to 3 spheres, one within the other - "The "space" of environmental education corresponds to the third of the following three interpenetrated spheres of interaction where the basic development of a person occurs" (see Figure 1 below).

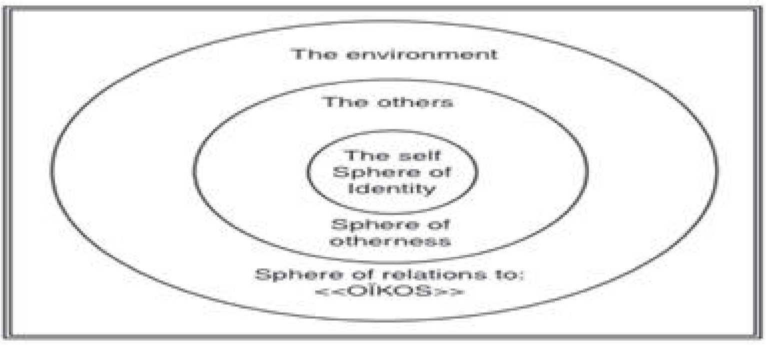

Figure 1: The three interrelated spheres of personal and social development.

The core or central sphere refers to the learner's own identity, the second sphere refers to the learner's interactions with other individuals or groups. The third sphere, then, refers to the biophysical environment which the learner is part of and the relationship the learner has with this environment, as conveyed through the sphere of interpersonal and social relations. Sauve noted of this third sphere that: "We also find here the integration of ecological education and economic education, both related to an individual's and a society's relationship to the "home"— oikos...Economic education helps to manage our relationships of consumption, organization, and exploitation of the environment as a "home" (it is not, in fact, a question of managing the environment but of "managing" our own choices and behaviours in relation to it)."

Tragazikis et al. (2009) noted that Sauve's concept for sustainability education as appropriate for the world of video games, noting that: "In a game a player adopts three different identities, the real one, the representation of the real one on the avatar and finally the avatar itself on the digital environment". They identified that, from an educational point of view, that learners should, through this process, develop a kind of "environmental morality" which can influence the learner's thoughts and actions and through which, learners should become aware of the the effects which their personal and social perceptions and actions have on their environment, through their personal in-game investigations. In this fashion, players can access a context for understanding complex systems related to environmental awareness. Tragazikis et al also drew comparisons between this process of learners adopting particular roles and perspectives in playing games and players occupying the zone of proximal development.

An additional important element with regards to education on sustainability is frequently to illustrate the catastrophic results of bad sustainability practice, such as global warming and deforestation, as a way of increasing this "environmental morality" - e.g.: environmental concern and/ or knowledge. Malone and Lepper (1987) noted that imagined scenarios, such as those found in digital games, can offer the learner the analogies or metaphors for real-world elements that allow the user to experience resulting scenarios or effects from such elements from multiple perspectives. Tragazikis et al (2009) seem to agree with this finding, noting that "material may be learned more readily when presented in an imagined context that is of interest than when presented in a generic or decontextualized form.".

A useful additional element with regard to this scenario-orientated approach is also that encourages to players to "think outside the box" in confronting problems and creating solutions. As noted by Thomas and Brown (2009) such approaches require players to carefully examine situational potentials. Kelly and Nardi (2014) see this as an extremely beneficial educational element in games, in particular for games that deal with issues of "futures of scarcity" in which environmental issues such as climate change, resource depletion and pollution must be considered by the player.

This transformative learning experience can help to both spark curiosity and foster persistence, opening students' minds to new possibilities. Furthermore, this ability, to "play out" representations of real-life scenarios (including, in the case of sustainability training, scenarios which would result in damaging real-life consequences such as global warming and deforestation) resembles another of Gee's learning principles, the "Psychosocial Moratorium" Principle whereby learners can take risks in a space where real-world consequences are lowered.

Bogost (2007) identified that a key element to teaching and learning with games was not necessarily changing behaviours, but fostering frequent deep thinking and having the learner consider both the positive and negative results of actions. The persuasive power of games can be used to elicit deep and lasting emotional responses or critical reflections in the player. Bogost identified these "Persuasive games" as a natural choice for many bodies such as advocacy groups and lifestyle brands who wish to persuade the player of a certain argument, noting that such games not only deliver messages, but also stimulate experiences - becoming rhetorical tools.

Indeed, this use of rhetoric is a key element for the use of games for sustainability education. Bogost, speaking on the ability of "persuasive games", makes the case for what he terms "procedural rhetoric" within games, which posits that games can make powerful representations of real-world practices, concepts and happenings, not only through the use of media, but also through the use of processes which they embody and models which they present. Bogost noted that a game need not have an obvious political or ideological message to do this, however, as he identifies that all games facilitate this simply by the manner in which they reward some actions while discouraging others, creating their own procedural rhetoric in doing so.

Games concerned with sustainability education, therefore can make strong rhetorical arguments that encourage more sustainable lifestyles, or can outline the dangers of unsustainable actions. Games such as *ElectroCity*, for example, require players to consider where their energy comes from and the consequences of this. Games such as *MiniMonos* demonstrate the potential dangers of living in an unsustainable fashion. Arora & Itu (2012) note that the trend in many games concerned with educational elements are able to indirectly affect players of their learning objectives by "attracting, engaging and sustaining the players in this game world and, through constructed narratives, fostering empathy for the characters and creating shared knowledge about the issue at hand, with the overall aim for personal involvement and activism towards the issue.".

Writing on the use of virtual tools and e-campaigns by INGOs to inform, communicate, educate and raise funds, Arora & Itu (2012) note that these methods "could be considered an innovative idea of using a non-mainstream channel (which, nevertheless, has a wide potential public) to disseminate information about social causes and reach the INGOs purpose of raising awareness and enhancing social change.". It is also worth noting that the use of games as a medium for education brings with is an additional, external factor, which is the community of gamers who play games.

3. Games

The range of games which deal specifically with sustainability education is not large. Typically, these games are serious games which are focused on a specific area of sustainability education (e.g.: *ElectroCity*). Many of these games also offer players the opportunity to develop their own values based on the information gathered within the games, encouraging players to use critical reflection and other metacognitive skills for transformative learning. However, there are a variety of games, from different genres and across categories, which can contain an element of, or can be used for, sustainability education.

4. Serious games

Serious games that are designed specifically for educational purposes are often suitable for use alongside traditional teaching methods in order to achieve various curriculum objectives. Games for sustainability education are no different allowing students, both formally and informally, to learn or revise content related to this important area. While the advantages of serious games often lie in the quality of the content within, they can also make good use of the motivational and engaging effects of games while also allowing users to explore the development of other skills (De Freitas, 2006). This motivation and engagement in turn increases the potential for knowledge acquisition and retention (Connolly et al., 2006) potentially leading to a change in real-life habits or increased awareness of important environmental issues.

Serious games for sustainability have taken many forms, from simulations to turn-based strategy games and the recent focus on sustainability and environmental education has seen a steady rise in the development of serious games in this genre. Simulations have their advantages for learning, as they require critical thinking rather than putting an emphasis on any traditional rote learning. But simulations are, in essence, overly simplified versions of environments and, games like *SimCity* and *Civilisation* in particular, are vastly complex in-game environments where users can essentially roam free. An old case study on the benefits of *SimCity* and *Second Life* as planning tools had pointed to a lack of fidelity in the responses and actions of the characters as a significant flaw but noted the use of evaluation tools such as graphs as aiding the analysis of decisions (Devisch, 1998).

SimCityEdu: Pollution Challenge! addresses these and other issues by adding structure and constraints to the environment to enhance learning and by chunking information and tasks into 10 minute sessions to make them more suitable for the classroom. The game, modified from the popular *SimCity* game series was developed as an educational game to teach students about environmental issues and pollution in cities and to provide an integrated assessment methodology for the students. The game encourages students to plan ahead but also take risks, and they become invested in the town they're creating, thus encouraging them to analyse the decisions they have made and plan for a more successful town in the future. *PowerUp* is a 3D action strategy game that focuses on energy, engineering and diversity, with the objective of the game being to generate clean energy while racing to save the planet from ecological disaster. Each area of the energy- themed worlds - water, solar and wind - has a major challenge to be solved, all with four objectives and clear measures of success. The game also allows players to interact with non-player character "engineer guides", whose personal experiences are provided by professional engineering societies from various diverse backgrounds.

Turn-based strategy games are particularly popular for sustainability education as they stimulate metacognitive skills, encouraging careful planning and strategizing and in some cases trial and error, in order for the player to successfully complete the games. Players are encouraged to analyse the pros and cons of decisions and, with reference to Gee's psychosocial moratorium, can see the results of these decisions in risk-free environments. Such games benefit from particular skills such as critical thinking, monitoring, self-regulation and decision making, as well as being effective tools for collaborative work. Turn-based games also add an addictive element to games, encouraging repeated playing in order to improve on the player's performance.

***ElectroCity*,** a turn-based strategy game follows a similar model to *SimCityEdu: Pollution Challenge!* whereby users in the role of mayor manage a virtual town with gameplay involving the particular management of issues relating to energy. The game development was funded by the New Zealand energy company, Genesis Energy with a view to increasing awareness of consequences of energy consumption and misuse. The larger aim of this game is to use critical thinking and decision making strategies to develop a town into a large metropolis all the while maintaining the satisfaction of the population. *Catchment Detox* is another turn-based strategy game but with a focus on water and the environment in and around catchment areas. The game requires the player to manage a virtual river catchment over a set period of time (100 "turns") whereby the player must make decisions on changing the landscape to facilitate activities and/ or deal with environmental problems. The overall aim of the game is to create an environmentally happy catchment with a sustainable and thriving economy. *Plan It Green,* developed by National Geographic, the Centre for Science and General Electric, is a strategy simulation akin to games such as *SimCity*, *ElectroCity* and *Catchment Detox* whereby the player, acting as mayor, must develop an environmentally friendly town by balancing energy resources and consumption. While targeted to younger players the game offers both a comprehensive tutorial and a large amount of prompting for the player within the game. The game includes educational videos and mini-games that can be accessed within the game in an effort to make the educational material as accessible as possible to the player.

ElectroCity and ***Catchment Detox*** take advantage of the particularly addictive nature of turn-based strategy games, using simplistic gameplay mechanics in order to challenge the user to improve their outcome. Generally, these games allow for risk free, experimental learning to take place as the user takes control of their virtual world under the guidance of their teacher. With the player assuming the role of mayor in these games and with the responsibilities that go along with that role, the chances of environmental morality having an impact on the player are higher. While the fidelity is low in such games, the focus on content and strategy allows players to increase their awareness of the topic albeit generally still with a large gap between value and action.

Garbage Dreams is a scenario-based strategy game, developed as an accompaniment to a documentary of the same name. The game utilises the turn-based game mechanic seen in a variety of sustainability games, along with a timer within the scenarios to lend a challenging aspect to the game. The game requires the player to sort and process refuse that has been collected in different neighbourhoods of Cairo. The player must invest in education for the city's population, suitable treatment or collection facilities for the various garbage types and expansions to other zones in the city. The ultimate aim of the game is to build up enough knowledge of the theme and strategise in order to successfully recycle over 80% of the refuse in the city. Due to the content of this game and the regulations in many countries with regard to waste management, there is a higher opportunity for the player to act on this knowledge in their day-to-day life. *Stop Disaster Game* is a scenario-based strategy game that presents various disasters to the player, including a tsunami, hurricane, wildfire, earthquake and flood, and requiring them to prepare the respective community for the natural disaster. The player, using limited funds, must provide evacuation plans, shelter and sufficient defences for the community to limit the amount of injuries and damage that could be caused by the disaster. Both of these games provide in-game information along with additional resources for teachers, offering a wide range of uses. The relatively short playing time (10-20 minutes) encourages repeated play and, as with the majority of these games, encourages players to reflect on the decisions that they made in the game and challenges them to improve their performance, developing both their procedural and conditional knowledge.

Perhaps a key aspect of these serious games for sustainability is the fact that many of these successful games have been funded by or have had involvement from energy companies (e.g. *ElectroCity, Plan It Green*), from government initiatives or strategies (e.g. *Stop Disasters Game*), and from research groups (e.g. *Catchment Detox*). This, along with an alignment to curriculum goals, has ensured that the games have relevance to current education and environmental priorities. Games such as *ElectroCity, Catchment Detox* and *Stop Disaster Game* place the player in a role with high responsibility helping to increase their awareness of and connection to the outcome of the game and the issues at hand.

5. Commercial games

The primary advantage of the use of commercial games for sustainability education typically (though not necessarily) lies in the strength of these games "as games". Commercial games tend to possess larger budgets, more experienced and intellectual individuals for development and the most up-to-date technical hardware and software, creating games which provides players with premium gameplay experiences. Commercial games, however, can tend to lack the specific objective of serious games as they are focused primarily on providing the most engaging gameplay experience to the player. Conversely, as noted by Jenkins et al (2003), serious games may often fail to engage players due to a less enjoyable playing experience (as a result of sacrificing rhetoric for gameplay), whereas commercial games, with their focus specifically on enjoyable game mechanics, can overcome this.

Games such as *SimCity* were early examples of games which confronted the player with choices and responsibilities related to sustainability and environmental morality. Decisions in *SimCity* require the player to decide what sources they would use to provide energy to their virtual cities and necessitate that players adopt a realistic viewpoint with regard to the advantages and disadvantages of each. For example, renewable energy sources required a comparatively large amount of real estate and produced less power compared to other sources such as fossil fuels which provided more energy and took up less space, but would create pollution, impacting on the health of residents. Nillsson (2008), for example, as part of a study which involved using *SimCity 4* to get students to create sustainable cities, noted that: “When deciding which power plant to install the students considered relationships between cost, amount of power generated, and environmental damage. They got to experience consequences of their actions and how they influenced the development of the city”.

Another commercial game for sustainability education is *Ludwig*, a futuristic physics adventure game requiring the player to learn about the need for renewable energy and the dangers of depleting fossil fuels. The player must explore a futuristic environment and discover ways of creating energy from that environment. This game was developed in tandem with research undertaken as part of a project studying motivation and learning transfer in serious games - “Research on motivational aspects and knowledge transfer in digital educational games for children aged 10 to 14 years”. Some results of this study showed that knowledge transfer was successful, but only when linked to existing problems or curriculum content and supported by the teacher (Wernbacher et al, 2012)

6. Satirical games

Another category often used in games is satire, which can promote more serious, educational messages in an attempt to ease the formality of such games and incorporate persuasive elements to trigger reflection and reaction in the user. Satire can be particularly useful in the area of sustainability education by demonstrating dangers and effects of poor environmental awareness through amplified, exaggerated destructive consequences of decisions within the game.

The game *Oiligarchy*, for example, aims to increase awareness of the West’s dependence on oil. The game melds the more serious issue of oil dependency at any cost with a casual game in an attempt to offer a persuasive message. *The McDonald’s Video Game*, is a satire of business and resource-type management games, similar to the “tycoon” series (e.g.: rollercoaster tycoon, zoo tycoon, etc). The player is required to manage the various aspects of a fast-food franchise, but in doing so, is required to take part in highly unethical practices in each area, reflecting the unethical practices implemented by such franchises nowadays. The issue of sustainable practice is central to the game's educational/ satirical purposes - most notably in sections where the player must allocate resources for pasture farming in South America, involving illegally clearing rainforests, corrupting climatologists to counter claims by environmentalists, etc. As the game progresses, the damage caused by these practices becomes clear to the player in the game, resulting in visual degradation of the land being used for pasture farming and in virtual criminal cases taken against the player.

Table 1 offers a summary of the commonalities across the aforementioned games and outlines the similar issues affecting many of the games, i.e. the generally larger gap between the value and knowledge gained in the game and the chance of the player acting on this in their day-to-day life. The table also highlights the popularity of the turn-based strategy games and the various opportunities for players to develop metacognitive skills through these games.

Table 1: Summary of popular games for sustainability education

Game	Type	Style	Key Skills/ Opportunities	Value/Action
ElectroCity	Serious Game	Turn-based strategy	Collaborative learning, strategic thinking, critical reflection, decision-making	High awareness but low-medium chance of acting on this in real-life scenarios
Catchment Detox	Serious Game	Turn-based strategy	Collaborative learning, strategic thinking, critical reflection, decision-making	High awareness but low chance of acting on this in real-life scenarios
Stop Disaster Game	Serious Game	Mission/ Scenario-based strategy	Collaborative learning, strategic thinking, critical reflection, decision-making	High awareness, high empathy but low chance of action
Garbage Dreams	Serious Game	Mission/ Scenario-based strategy	Strategic thinking, decision-making, critical reflection	High awareness and medium-high chance of real-life action
Plan It Green	Serious Game	Mission/ Scenario-based simulation	Collaborative learning, strategic thinking, critical reflection, decision-making	Medium-high awareness and medium chance of acting on this in real-life scenarios
PowerUp	Serious Game	Strategy	Strategic thinking, decision-making	Medium awareness and low real-life action
Sim City	Commercial Game	Simulation	Strategic thinking, decision-making	Low-medium awareness and low real-life action
SimCity EDU	Commercial Game	Mission/ Scenario-based simulation	Collaborative learning, strategic thinking, critical reflection, decision-making	Medium-high awareness, low chance of acting on this in real-life scenarios
Ludwig	Commercial Game	Adventure	Strategic thinking, decision-making	Low-medium awareness, low empathy and low real-life action
Oiligarchy	Satirical Game	Scenario-based simulation	Strategic thinking, decision-making	Medium-high awareness and low chance of real-life action
McDonalds	Satire Game	Scenario-based simulation	Strategic thinking, decision-making	Medium-high awareness and low-medium real-life action

7. Conclusions

As noted by Suave, the role of ecological education "is not, in fact, a question of managing the environment but of “managing” our own choices and behaviours in relation to it". Recurring themes which emerge from the literature related to sustainability education is the creation of “values” within the learner. Terms such as “ecoliteracy”, “ecological intelligence” & “environmental morality” are terms embedded within sustainable development education and which appear in the literature to suggest that the purposes of sustainability education processes are not only to develop knowledge and skills within the learner, but also to develop core character attitudes and biases which are closely tied to the environmental obligations each learner (as a member of society) bears.

To suitably meet the challenges of creating or harnessing this type of education, an educator must therefore look to develop educational material which goes beyond simply presentation and assessment of information, but which offers an educational solution which is immersive, engaging and emotive. As identified in the paper, the use of digital games as a tool to provide such an educational solution is a compelling argument. The ability of digital games to neatly align with Sauve's concept for sustainability education, as identified by Tragazikis et al., as well as the persuasive power of games and their ability to elicit emotional responses and/ or critical reflections in the player, as identified by Bogost, are but two strengths which games possess. Coupled with the other educational opportunities offered by games - such as allowing the learner to reflect on both the positive and negative results of actions, providing the opportunity to "play out" representations of real-life scenarios, utilizing procedural rhetoric to make strong rhetorical arguments to the player - all help to facilitate the transfer of knowledge while also providing players with a deep emotive experience.

A critical issue, however, which emerges when examining the use of games for sustainability education, lies in the gap between values and action, with most selected games, when examined, seeming to offer little in attempts to progress the player from learning in the game to taking real-life action(s). As games for sustainability education seek to foster values and attitudes within the player, the lack of transfer from the game world to the real-world therefore represents an unfortunate "missed opportunity" - as games do not capitalize on the values and attitudes they attempt to embed in the player by failing to propel the player into taking appropriate real-world actions for sustainable development. In this regard, the use of games for sustainable education could be greatly improved.

Games for serious education could follow the examples set by a number of existing serious games related to social issues, which are far more effective in implementing real-life change on the basis of educating players through game-based-learning. One such game, a Facebook game *Half the Sky: The Game*, ties in-game activities to real-world charitable opportunities whereby, as players complete certain elements of the game, they receive prompts to donate to real-world causes or can unlock donations from sponsors of the game, including medical resources, resources for surgeries and books and other learning materials. Similarly, another serious game developed in 2011, *Darfur is Dying*, served to provide in-game prompts to players, based on their in-game activity, to donate money or to send emails directly to politicians in an attempt to help address the Darfur crisis. These type of in-game ties to real-life activities, lacking in the vast majority of games dealing with sustainability education, would greatly help to strengthen the effectiveness of such games if correctly implemented and would certainly help to improve the use of games as tools not only for sustainability education, but also as tools for real-life sustainability promotion and/ or implementation.

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Failure's Paradoxical Relation to Success: What Games can Teach us That the Academy Misses

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Abstract: This paper explores the relation of chaos to pattern in Wolfram's Rule 30 en route to exploring the essential role failure plays in the success of a game. Tentative pattern identified in the face of game chaos encourages the player to postulate new patterns that aid in dealing with failure. Identification of a usable pattern provides cognitive traction for a player attempting to overcome odds, discern relationships, vanquish menacing opponents, and consolidate winning strategies that temporarily stave off disaster. In a good game, there is just enough pattern for a good player to identify and thus win. In a great game with only evanescent pattern, a great player sustains temporary success by learning from failure. Games can therefore teach higher education a paradoxical lesson it currently poorly understands--namely, that failure has an essential role to play in academic success.

Keywords: Wolfram Rule 30, pattern, academic failure, failure in games, degenerate strategy, player failure and game success

1. Introduction

A paradox that haunts the academic community can be illumined by and perhaps even redressed significantly by game play. Notably, academic failure has such undesirable connotations that, ironically, the academy has largely failed to understand how important failure is to success. Comparatively little has been written about the positive dimensions of academic failure at the collegiate level and even less has been written about the positive role failure can play in genuine education and life experience more generally. In a word, in a rush to embrace mono-dimensional excellence, the academic enterprise has been taken in by the siren song of success and has eschewed the deepening, enriching experiences of failure. Perhaps no area of human experience can serve as a better corrective to this venerable misunderstanding than games, game play, and the essential role of player failure in great games.

The purpose of this paper is to explore the critical role of failure for significant games so that we can redeem failure as a necessary experience for significant education. In a good game, the prospect of failure provides the incentive for learning the game. In a great game, as in larger human challenges, the player strives heroically to stave off chaos by seizing pattern and imposing order when chaotic disaster appears to be not only imminent but finally insuperable. As a result, failure is an essential ingredient in profound success, a lesson which games can teach the academic enterprise.

The three major parts of this paper include, first, a discussion of the literature related to conventional views of academic failure; second, an exploration of Wolfram's celebrated Rule 30 whose importance to computer science is well known but whose relevance to understanding game pattern recognition has not been highlighted; and, third, the experience of a grant-funded experimental course, "Game Programming on the Web," which attempts to identify the mechanics of how failure is important to successful games. Concluding sections explore degenerate strategies and the paradoxical relationship of player failure to game success.

2. Conventional views of academic failure

Conventional views of academic failure are pervasive. For example, Rafoth (2004) articulates what at first looks like a perfectly sensible view of academic failure:

> *Preventing academic failure means that we, as a society, are much more likely to produce individuals who feel confident about their ability to contribute to the common good ... Thus the prevention of academic failure should be a primary concern for any society.*

Following in the venerable trail blazed by Pitcher and Blaushild (1970), we read a litany of reasons why failure is academically irredeemable, most of which echo the conventional (and often defensible) reasons why individual failure has such undesirable social ramifications. Notably, there is no attempt to discern whether failure might have some redeemable qualities and might, in fact, be among our most important, instructive experiences. Salau (2014), writing from an African perspective, more readily recognizes that students should "handle failure so as to get the best out of it," but the work's brevity precludes a substantive discussion. Davis (2013) astutely observes that elite educational institutions stand furthest from "successful failures" and has some useful generalizations about failure, but does not mention how instructive games can be in this regard.

More generally, the academy has been better at identifying causes of failure—notably, how failure might be avoided—than in coming to a considered view of how failure can be important in education. For example, the University of Alabama's "Causes of Failure in College" identifies ten deficiencies in students that lead to failure rather than attempting to identify how failure might be an inexorable part of complex tasks in real-world challenges, that collegiate education ought to anticipate and perhaps even simulate. Kravosky (2004) does better in suggesting that any study of success that does not include the role of failure "tends to create a misleading—if not entirely wrong—picture of what it takes to succeed" and we get some hints from Smith (2015) of how failure might be redeemed, but little more.

We do better recalling a justly celebrated Stanford Commencement address with more than 20 million YouTube views. Steve Jobs' story is well known but perennially instructive. He dropped out of school, eventually started Apple Computer, then was fired from his own company, "a very public failure." But he claims in the address that "getting fired from Apple was the best thing that could have ever happened to me." This public failure was an essential ingredient in perhaps the most storied, successful business career in tech history. Jobs spoke eloquently of the inexorable failure of death that gets us out of the "trap of thinking we have something to lose." Evidently, Jobs understood better than his distinguished audience just how important failure is to success.

3. Cellular automata, chaos and complexity

Cellular automata (CA) have been studied extensively since work of von Neumann (1966). A two-dimensional CA will have a primed top row and calculated successive rows, which are determined recursively by applying the CA rule to each row. Like a conventional computer, elementary cellular automata are digital and binary, with each cell taking either a 0 or a 1, determined by the CA rule. As a result, the evolution of a CA is determined by a table specifying the state a given cell will take in the next generation. Figure 1 illustrates this, using Rule 30.

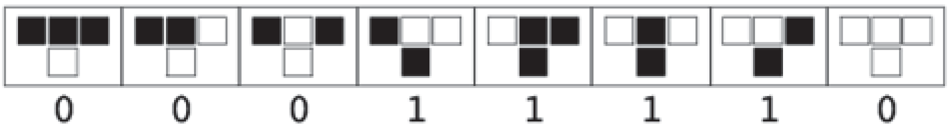

Figure 1: CA cells take either a 0 or a 1 in an elementary CA such as Rule 30. There are 2^3 possible binary states comprising its rule, since each place has one of two values, depending on the state of the three previous cells. This simple table computes the entire run of the CA, which is extraordinarily complex

For example, when the three preceding cells are black (the first cell on the left), the rule specifies the new cell should be white. When the three preceding are black, black, white, the new cell is also white. But when the three preceding are black, white, white (the fourth cell from the left), the new cell is assigned 1 or black.

There are four classes total, according to Wolfram's (1994) scheme. Class 1 runs and then dies out. Class 2 is orderly with a repeating pattern. Class 3 may have some local pattern but has no overall, identifiable pattern. Class 4 (see Fig. 2) contains both Class 2 and Class 3 elements and is pertinent to the psychology of game play as well as countless other complex adaptive systems.

Important for discerning some of the implications for game play, the connection between nonlinearity and computational irreducibility is critical since there evidently is no generalizable way to predict the behavior of Class 3 systems. We cannot expect such a method or formula to emerge; in fact, that is one way to define a great game. A great game, in other words, cannot be "gamed." While there will be occasional identifiable patterns in a Class 3 CA, which can provide important cognitive traction (Freeman 1992), there is not the sustained pattern necessary to get a sense of the CA more generally. That is, there are no Rule 30 cheat sheets. It remains an evanescent enigma, closed to formal analysis and any broader understanding. Effective cheat sheets for games, in fact, are evidence that a game could be richer, deeper, more complex, more like life, and more like a good Class 3 CA.

Figure 2: Class 4 CA: Complex Pattern. Wolfram Rule 22 generates this complex CA (rows 0 to 1530). We seem to have a perfectly predictable pattern but closer examination shows that each iteration of the structure differs from earlier ones and the difference is unpredictable. Nonetheless, we have some cognitive traction and some ways to characterize it non-trivially

4. Rule 30 and the specious search for enduring pattern

Perhaps the most studied and even celebrated Wolfram (2002) CA, aside from Rule 110 and its proven Turing completeness, is Rule 30. Rule 30 is usually classified as a Class 3 system, which means it is fundamentally chaotic. As illustrated earlier in Fig. 2, Rule 30 takes its name from its binary rule, "00011110," which is 30 decimal. The general consensus is that Rule 30 is chaotic but this is not a probable result and Rule 30 runs tease us with the repeated appearance of pattern. That is what makes it tantalizing and pertinent to the psychology of games.

Rule 30 generates a complex, almost certainly chaotic pattern of indefinite length. Wolfram (2002, 15) believes it repeats, but with a period of "a billion billion times the age of the universe." It is impossible, of course, to test this hypothesis. Accordingly, it is reasonable to conclude it is effectively infinite in size—that is, it is impossible to state categorically that there is no pattern that repeats. But for our purposes, it does not matter. What matters is that the search for a repeated patterns comes close—but never, so far as we know, gets an exact match. Rule 30 beckons, like a siren song from Greek mythology, it tantalizes, but resists our attempts to characterize it by means of a pattern.

As illustrated in Figure 3, Capture 1 with two larger triangles looks like a possibility for a match, but it fails, of course, because the triangles are differently aligned. Even the smaller triangles do not match. So there is a casual-glance similarity, but its solicitation turns out to be specious. Capture 2 has the angle right but the sizes wrong. As well, it has a "grill" not present in the original. Closer inspection startles us with the many ways similarity can vary from identicality.

Rule 30's allure has kept researchers looking for decades (Gage, Laub, and McCarry 2001; Martin 2008). Capture 3 has the right angle of the two triangles but it is mirror imaged. The smaller triangles come close to matching but, once again, we are disappointed. The closer we look, the more the initial hope for similarity fades. Capture 4 has the right angle of the triangles but, alas, they are too large. The other triangles are an exercise in applied dissimilarity. Capture 5 has about the right angle, but the triangles are too far apart. And it is much too busy with a host of medium-sized triangles that are not present in the original. Each comparison reveals at best a weak fractal relationship: similar but different and the differences accumulate the more we look. Initially, it looks promising, but closer inspection disappoints. Self-similarity, we repeatedly learn, is not identicality.

Capture 6 also has the right angle and the relative sizes of the principal triangles seem promising, but they are too far apart. The other triangles excite with their similarity but there is still no match. Capture 7 almost immediately fails for multiple reasons, despite specious initial impressions. Capture 8 has the right angle but the wrong size for the upper triangle. We learn repeatedly how many ways a pixel arrangement can be similar but not identical.

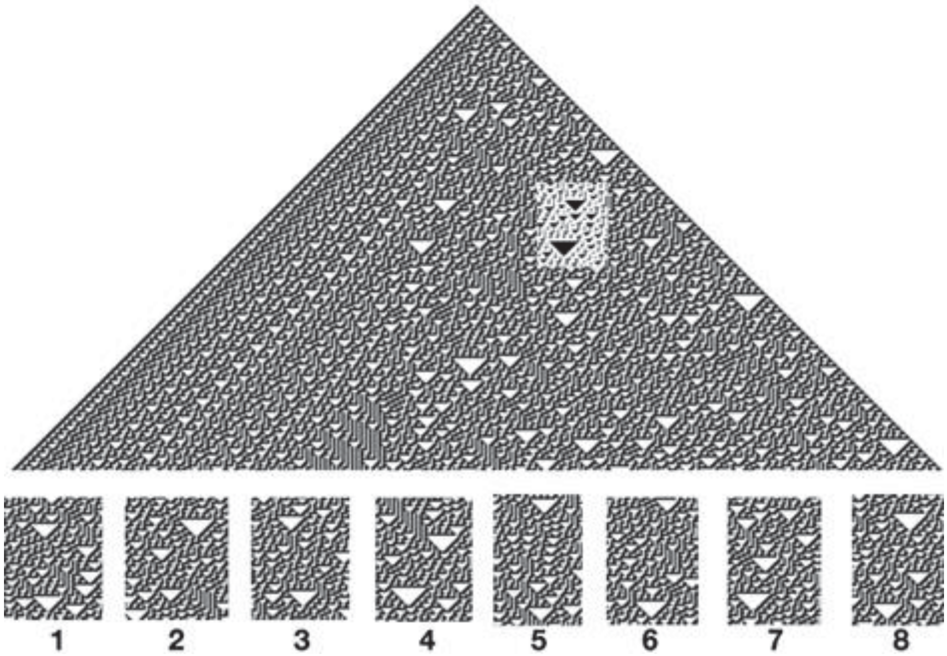

Figure 3: Search for Pattern in Rule 30. Wolfram Rule 30 generates a CA with pattern on both sides but these are artifacts and wash out when the CA is wrapped cylindrically. Here one pattern is highlighted and a search is made for matches in later sections. Rule 30 tantalizes but never yields, as far as we know, a match of two sets of patterns. Section 2 comes the closest but a moment's study reveals it too fails to match

So this evidence suggests we are are unlikely to find a pattern. But, notably, each search failure can still have significant instructive value (Jiang, et al. 2015). When we become experienced at coming close to matches, we learn a generalized sense—not easily captured in a formula—of what to look for in pattern. Pattern recognition is a largely preconscious, embodied skill (Margolis 1990) that every game player must cultivate. But pattern questions are just as important in academic work, business, and political leadership. When is some evidence of pattern enough, given limited resources? How is an economic recovery like and not like a previous one? Every attempt at real-world pattern recognition must inevitably fail, but as we learn from failed attempts at pattern recognition, we sometimes can identify limited patterns with temporary utility.

The parallel between Rule 30 and great games is therefore instructive and warrants more research. Some important questions are: What is a pattern? What is the psychology of patterns that are similar but not identical? If Rule 30 is computationally irreducible, and the evidence suggests it is, to what extent is pattern similarity computable? Are all great games similarly computationally irreducible?

5. Programming to learn from failure in "Pirates & Navy"

In a senior-level course funded for the last two years by an Innovation Fund grant at Augsburg College, Minneapolis, MN, USA, CSC 495, "Game Programming on the Web," one student assignment is the game "Pirates & Navy," as illustrated in Fig. 4. The game is principally written in JavaScript and enables the complex graphics supported by HTML5's Canvas element. Canvas supports scriptable rendering of 2d images that constantly refreshes a low-tech bitmap but, when done well, supports an immersive, compelling graphics experience for the player.

Figure 4: Programming for Failure. The "Pirates & Navy" assignment in CSC 495 instructs students to write the game so that it has the usual roster of perils, such as pirates, sea monsters and hurricanes, but has mechanics so that the player can learn from "failed" encounters

As a result, since games are an exceptional way to learn programming, students learn a great deal about JavaScript HTML5 Canvas, and game design. But they learn a lesson far more compelling—and much less common in the academy more generally—when they learn to program the game so that the player can learn from being swallowed by the sea monster or being sunk by pirates hiding behind a fast-moving storm. Namely, they confront directly Steve Jobs' question of how we can learn from failure. The assignment calls on them to build into the player experience of the game the possibility and the necessity of learning from failure. They confront daunting questions such as, "What is failure?" "How might an experience of failure turn out to be instructive?" and, "What does the failing player need to look for in the failure so that it can be a learning experience?" The parallel to searching for pattern in Rule 30 becomes obvious.

In thinking through how to program the game so that the player can learn from failure, I believe they learn how to watch their experience more generally so they can identify sometimes implicit dimensions of failure that can be even more instructive than facilely acclaimed success. Such learning involves identifying patterns that endure for a time but, like those in Rule 30, inevitably fail if we count on them being permanent. One astute programmer suggested, "Players need to look more closely for dimensions of a failure that might disclose how to do better the next time and programmers need to make it possible for the player to learn from failure. The player should not see failure as defeat but as a complex riddle to be unravelled, in preparation for the next, more complex challenge." Like a complexity theorist perusing a Rule 30 run, players and programmers need to become better at identifying the ephemeral differences between genuine repetition in pattern and the appearance of repeated pattern.

Moreover, the course required them to think through their game mechanics so that failure can facilitate learning rather than engender psychological defeat. In a word, a great game does not mean avoiding failure, as the academy often imagines, but confronting failure as perhaps the best way to learn. More than the academy, games call the question of the meaning of failure (Juul, 2013), whether it can be viewed positively, and how it ought to be risked routinely. One student programmer asked me, "Do faculty also attempt to identify how failure in a conventional course can lead to learning in a way similar to how games should be structured?" Speaking from my own experience only, the only response I could marshall was, "We are so geared to looking for success and disowning failure, we don't think through it productively."

In conventional academic settings, that is usually how we see failure. As a result, we don't teach students to learn from failure and generally the academic system is structured most to encourage risk-averse behavior. Indeed, we have not only created a generation of risk-averse students (Buonanno and Pozzoli 2007) who see failure to be avoided at all costs, we are creating millions of risk-averse graduates.

6. Degenerate strategies in games and risk-averse academic study

A degenerate strategy is a way of playing a game that exploits an unintentional design weakness so that it becomes easier for the player to win. Degenerate strategies do not involve rule violations but they prevent the game from being experienced in the manner intended by the game designer. They shortcut the game so that it is not experienced in the way intended by the designer.

Students in CSC 495 were typically appalled when they discovered a degenerate strategy for the game they had written since the discovery of such a strategy not only meant they were guilty of a design error; more importantly, it meant that their respect for the game they had written plummeted. But I was surprised by how often they looked for such strategies in their own games. It turns out that players hunt relentlessly for degenerate strategies but degrade their estimation of a game when they find them—winning with a degenerate strategy generates contempt for the game.

We may find the parallel with collegiate education disconcerting. Students either explicitly or unconsciously often employ degenerate educational strategies. A great game cannot be gamed by degenerate strategies but evidently (Winch 2016) much of the academy can be gamed. This can mean obvious degenerate strategies such as petitioning for credit for less rigorous prior work or it can take the form of risk-averse behavior such as avoiding more challenging classes so failure is not even risked. In fact, one way to view grade inflation is that it reflects the degenerate strategy of risk aversion. Failure avoidance in students is exactly analogous to degenerate strategies in game play and we should wonder about the ramifications for the educational enterprise and how well it prepares students for inevitable career failures. We may not be preparing many future Steve Jobses for the creative destruction—and massive risks—of the modern, computationally infused, global economy.

7. The paradox of player failure and game success

Interest in serious games, of course, has accelerated dramatically in recent years, especially in the academy (Berg 2009). That much is widely known. What is less well known is how dramatically interest in "failure studies" has accompanied academic study of games and how this research can be put to productive use.

The paradox of player failure and game success is that an engaging game must tantalize the player with the slender possibility of success but, like Rule 30, resist it at every turn. To put it another way, the juxtaposition of pleasure with pain must be much like the relation of Class 2 order with Class 3 pain, in the "edge of chaos" described by complexity theorists. The search for pattern matches in Rule 30, against the backdrop of knowing how it allures but always disappoints, parallels the search for success in a game even as the player knows that failure is never far away and, for the best games, that it is inexorable. It is the inexorability of failure that contextualizes and enriches the intense pleasure of temporary success.

The paradox is illustrated in hearing a player exhort, "I hate this game, this game is completely unfair!" as the player considers throwing the console through the window. Only if the exasperation is comprehensive, however, can the pleasure in temporary success be deep. Failure must embroider the ephemeral chance for success if deep pleasure is to develop. As Frost (1939) wrote, "It begins in delight, it inclines to the impulse ... it runs a course of lucky events, and ends in a clarification of life, not necessarily in great clarification ... but in a momentary stay against confusion." Success in a rich game that parallels life, like an exploration in Rule 30, is delightful even as we recognize that all we can achieve is a "momentary stay against confusion." Success in a video game is a momentary stay against the confusion of chaos even as success in life is a momentary stay against death.

But what does the prospect, even likelihood, of player failure entail for the paradoxical success of the game itself? When we are likely to lose but want desperately to win, it binds a player to a game in a way that easy success never can. As Sylvester (2013) argues, when we lose in a game, we are responsible for the loss more than a reader of a play witnessing the death of a beloved character. Failure in games highlights the inadequacy of the player in the starkest terms. Failure is not only experienced as real, it is personal. It is often obvious for all to see. The significance of the failure is measured objectively and often brandished with chartreuse numbers against a tenebrous background.

The paradox is even deeper. As Juul (2013) points out, speaking of himself as a player, "I dislike failing in games, but I dislike not failing even more." Generally, in other areas of human activity, we strive to avoid failing, but the likelihood or even inevitability of failure is a necessary condition for the pleasure of games. Like the necessary proximity of order and chaos in a Class 4 CA, order and chaos need to be closely juxtaposed for a game to be psychologically compelling.

The pedestrian view of video games is that they are trivial exercises in fleeting excitation, that they aim to produce juvenile "fun." Juul's thesis is that this is not only shallow but fundamentally mistakes the point of a great game. We need to be empirical about this—facial and vocal expressions of players immersed in a sophisticated game tell a different story than the pedestrian view just mentioned. It may be a facile truism that people are motivated by success, but game players are most exercised by anxiety-arousing immersion in the overwhelming likelihood of failure and ignominious defeat. Players grimace, groan, howl and hurl expletives. The pleasure emerges in the grim prospects unfolding on screen.

There is some parallel, Juul suggests, among theatre, film and video games in that tragedy is a necessary ingredient. Aristotle (1997), of course, argues that catharsis is the aim of great theatre, and a conventional understanding of games is that they are like theatre and film in this regard. But Juul takes exception to this comparison—something finally more interesting is transpiring in games. Remarkably, gamers want to experience what they dislike the most. Games don't purge pre-existing anxiety and hostility; instead—and this is the heart of Juul's thesis—they are designed most of all to create and sustain them.

Some game examples warrant comment. Recently, one of the hottest single-player games was "Flappy Bird," a dauntingly difficult game involving piloting a bird through narrow gaps. Like games dating to classics such as Tetris or Pac-Man, there is no way to win. Success is measured by staving off failure, by staying alive as long as possible. Flappy Bird is so challenging that a typical game often has the duration of a ride on a bucking bronco. Players loved it. As another example, "Super Meat Boy" was intentionally designed to be less forgiving than "Super Mario," with the result that an early death is more likely. It received high praise from a variety of critics such as Bramwell (2010), who comments that "at times it is viciously difficult." How far we are from conventional academic practice in such games.

8. Conclusion and outlook

The paradox of player failure and game success is that an engaging game must tantalize the player with the slender possibility of success but, like the forlorn search for pattern in Rule 30, resist it at every critical turn. The determined search for pattern in a game occurs even though the player knows that failure is never far away and, for the deepest games, that it is inexorable. It is the inexorability of failure that contextualizes and enriches the intense pleasure of temporary success, what the poet Robert Frost called a "momentary stay against confusion."

Gamers thus have a more sophisticated understanding of the crucial role of failure than professional academics. The sociology of academic failure is so toxic, in fact, that it exacerbates the demoralization and embarrassment that counterproductively attach to failure. Instead of recoiling or attaching sometimes irremediable stigma to failure, we ought to be teaching students how to learn from failure. Alas, as Winch (2014) has observed, "failure might be a great teacher, but it is also a cryptic one." It is time for the game community to highlight the essential role of failure for education so that failure will be less cryptic, better understood, and more fully embraced for the great teacher it can be. Making failure a less cryptic teacher, as a result, warrants a major research effort.

Games can thus teach higher education a paradoxical lesson it currently poorly understands--namely, that failure has an essential role to play in academic success.

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The JamToday Network: Towards Applied Games for Learning Environments

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Abstract: In recent years, the Game Jam approach has been increasingly effective in bringing appropriate stakeholders together around broad themes and challenges. There is now also a need to focus on establishing a sustainable learning hub for raising awareness of applied games addressing different themes and their use within learning environments. The European Game Jam Network, JamToday (www.jamtoday.eu), is establishing a central networking hub for the sustainable implementation and uptake of the next generation of educational games across Europe. Game Jams have been instrumental in stimulating innovation in the creation, implementation and deployment of educational games. JamToday is supporting this by creating toolkits and providing support for events across Europe, at local, regional and national levels. The JamToday hub thus provides stewardship for this emerging area and ensures that stakeholders maintain a balanced understanding of the main issues and the implementation hurdles that need to be overcome. JamToday seeks to provide a replicable model of good practice in the design of transformative environments and to provide methods and tools that have been validated from several perspectives. Each year, JamToday sets up game jams at several locations across Europe, focusing on a different theme each year. Combining observatory and knowledge-base functions, JamToday provides methods for measuring and assessing the impact of different approaches. This paper presents early results of the first European applied game jam network. It presents the work achieved by the JamToday Network to date and details of the practical tools and methodologies developed by the JamToday Network to support game-design approaches for learning environments from design to transfer and evaluation.

Keywords: game-based learning, applied-game design, game jam, co-design

1. What is applied game design?

Game-based learning has gradually gained recognition at policy and academic levels and many universities offer training and research in *'serious games'*. However, in many instances the serious games being developed sacrifice fun and entertainment in order to achieve a desired effect, resulting in a poorly designed solution that is rarely accepted by the intended users.

The European Game Jam Learning Hub, JamToday is a pan-European network that seeks to support the development of game-based prototypes through so-called game jams. JamToday's approach to game design is based around the idea of 'applied games'. Van Roesel et al. define applied games as *'games that are deployed for purposes like training, education, persuasion, physical exercise; i.e. all games that bring about effects that are useful outside the context of the game itself'*. (Van Roesel, L. and Van Mastrigt-Ide, J., 2011). In this approach it is the way that a game is *applied* that defines its usefulness outside the *context* of the game itself. At the core of this approach lies the idea that applied game design tries to retain core game design concepts in the wider areas of application and the broader context of use. Indeed the approach has been deployed across many diverse fields, from education and healthcare to defence and museums.

However this is a complex process, as finding a good balance between the *fun* and the *applied* part of the game is often a challenge. Moreover, people who work in game companies are mostly not experts in the field for which the game is being created. For these reasons, the JamToday network aims to build bridges between game designers and other stakeholders in order to maximise the impact of applied games. The Game Jam is the instrument used by the JamToday Network to create these bridges and to develop game concepts for specific thematic areas. JamToday provides a replicable framework for the co-design and co-development of game-based prototypes for learning environments. It also provides tools to facilitate the implementation and validation of game prototypes in learning and training contexts.

2. Games for learning and training environments: The policy context and main barriers

Over the last decade, the European Learning and Training sector went through significant changes supported by central authorities at national and European levels. For example, with the European Framework for Key Competences for Lifelong Learning, we observe that the focus is shifting from the provision of *knowledge* towards the provision of *competences*. The Europe2020 Strategy (European Commission, 2010) also calls for further innovation in the education sector as one of the key elements in smart growth for Europe.

Over recent years, the value of game-based learning has slowly been recognised and initiatives are emerging to support game-based learning in formal education programmes. In order to support further use of games in education, the European Schoolnet and the Interactive Software Federation of Europe have, for example, recently organised a set of online workshops on the use of Games in Schools. As the use of games by children is rivalling that of television (Greenburg, B., 2004) and studies reveal that young people all over Europe are playing computer games on a regular basis, the recognition of the value of games in learning to support the development of key competences is slowly emerging (Blamire, R., 2010). However, educators have been ambivalent about this, as technology is still only marginally applied in educational contexts (European Commission, 2012).

In a “Report on the educational use of games", McFarlane et al. (2002) explain the value of games in learning contexts by pointing out that “there is a widely held view that games software is capable of developing a degree of user engagement which could be usefully harnessed in an educational context". The area of game-based learning and digital game-based learning and teaching examines all types of digital games use from the perspective of learners and teachers (Stewart, J. & Misurca, G., 2013). It is a relatively new field, which has only recently been reviewed, and has largely focused on school-based education and some aspects of life-long learning (see for example Egenfeldt-Nielsen, S., 2005, Ellis, H., 2006, FAS. 2006). However, the value of using game design principles to address the needs of the learner has proven to be an innovative addition to traditional teaching methods.

Learning is perceived by most researchers as a multidimensional construct of learning skills, cognitive learning outcomes, (e.g. procedural, declarative and strategic knowledge), and attitudes. The state of the art pedagogy indicates that “designing effective learning environments where knowledge is generated from integrated experience with complex tasks may be more appropriate for many domains of learning compared to isolated, instructivist activities that separate knowledge from action and theory from practice, like learning and practicing separately” (Vygotsky, L.S. 1978). Computer games have great potential to provide such learning environments. (Cagiltay, K., Reinhardt, R., 2010). As such, games have a power of engagement that can be explained via intrinsic motivation, reflection and transfer (Habgood, M.P.J., 2007).

Indeed, "Like any innovation, games must be deployed in a measured and systematic way that maximizes their benefits while minimizing the negative consequences" (Marquis, L.., 2013). The discussion over the inclusion of games in learning environments has been running for some time and can be characterized in the following ways. For some, there is little place for games and gamification in education. This argument rests primarily on the absence of empirical evidence showing that real learning takes place and secondly arguing that skills acquired through gaming are not transferable to the real world. Other negative issues include: the cost of introducing games, distraction form learning other skills, social isolation and shortened attention span.

Furthermore, a Report published by the European Schoolnet 'How are digital games used in schools?', found that the main obstacles mentioned for not using games in school were (in ranking order): 1) cost and licensing, 2) timetable of the school, 3) finding suitable games, 4) attitudes of other teachers, 5) training and support, 6) inappropriate content, 7) worries about negative aspects, 8) insufficient evidence of value, and 9) examinations (Wastiau, P., Kearney. C., & Van den Bergh, W. 2009). Moreover, despite a rise in the recognition of the value of game-based learning, some authors point out that often little attention is given to how to implement them in learning environments and how to ensure there are significant learning outcomes. (Shaffer, D.W. 2009)

3. The JamToday network

Based on a thorough literature review and consultation with experts, JamToday has developed a framework with validated methodologies and tools to harness the potential of game-based learning from design to deployment and evaluation. Consisting of 25 original partners from 11 countries, the JamToday Network seeks to provide a replicable model to provide concrete answers for the introduction of applied games into learning environments. Through the active involvement of different stakeholders in so-called game jams for the development of game-based learning prototypes and by providing guidelines on how to implement these educational games in thematic areas, the JamToday Network seeks to provide a replicable model to bridge the gap between game professionals and professionals from the context of use. In this way, the JamToday network aims to engage teachers in the design and deployment of game-based learning prototypes thus raising awareness about the potential of games for learning and training environments and supporting the deployment of games into learning environments.

Game Jams have been successfully organised for several years around the world and are a powerful instrument to stimulate innovation in the creation, development and deployment of educational games. They offer the possibility to develop an idea into a potentially innovative solution around specific themes while at the same time offering the opportunity to explore the process of development (e.g. programming, game and interaction design, narrative exploration or artistic expression). Typically game jams last 48-hours. Over a weekend people from different sectors are brought together to brainstorm and develop game-based solutions for tricky problems.

Each year, JamToday sets up game jams in several locations across Europe focusing on a specific theme. In order to assist game jam organisers, the JamToday network has developed an online Toolkit that provides a detailed overview in 5 modules of the different steps to organise a successful game jam. The JamToday Tookit is conceived as a step-by-step guide explaining how to run a game jam following the JamToday formula and how to implement the outcomes into learning environments with the support of the JamToday network. It deals with aspects such as:

- Stakeholders and target participants
- Legal aspects
- Funding and finance
- Communication and Promotion
- Practicalities
- Transfer and assessment

Figure 1: A module from the JamToday toolkit

The JamToday model is open, transparent, versatile and replicable. While game jams are at the core of the approach, the JamToday network is more than a platform seeking to bring people together for just a weekend.

Prior to each game jam, JamToday fosters the identification of the most relevant regional stakeholders to invite to take part in the game jam for maximising the impact. JamToday provides guidance on how to carry out a stakeholder mapping analysis and how to mobilise the right stakeholders before, during and after the game jam.

These are, for example, game and sound designers but also thematic experts, teachers, parents, problem owners, investors, representatives from local and regional authorities etc. In this way, JamToday aims to make the processes involved in the creation of applied games more transparent to all stakeholders by providing the necessary know-how and expertise and by bringing together the different people who are involved in these processes.

In order to be the most effective, JamToday also provides tools to assess the potential of applied games and a framework to evaluate the best outcomes from each game jam. At the end of each game jam, a jury assesses each game prototype. Following that, a group of experts further evaluates the best outcomes of each game jam on different criteria:

- Game transferability in the learning sector
- Coherence with the proposed assignment
- Pedagogical potential of the game
- Innovativeness of the games
- Motivation

Ultimately, after the evaluation of the potential of a game concept, prototypes should be introduced into the thematic area. It has to be noted that the outcomes of game jams are prototypes that cannot be treated as fully functional and completed games in transfer activities. The JamToday Network has therefore developed a set of versatile tools to facilitate the implementation of these educational game prototypes into learning and training contexts:

- GameScope is a tool developed to validate/evaluate the potential of game prototypes and to learn to critically analyse a game prototype and discuss elements that make a good concept
- GameSpark is another tool that was developed to evaluate a playable prototype of an applied game. Since the tested game prototypes are in a very early stage of development, GameSpark seeks to gather data on the potential for further development rather than actually testing its effect. GameSpark consists of a Teacher Expert Observer Form **(**TEOF**)**, and a Student Expert Player Form (SEPF). The SEPF is developed in two versions; a version for the very young (SEPF Junior), using very basic questions and smileys as answer scale, and a version for older children.

Figure 2: The GameScope validation instrument

To support the transfer to Learning and Training environments, JamToday also hosts workshops with professionals from the learning sector aimed at introducing the best games from the JamToday game jams into educational environments and to enable educators to use these games in their classrooms.

4. Lessons learned: Annual theme - improving ICT skills

Each year, JamToday tackles a specific thematic area and consults with experts and professionals from the area of application in order to best address the theme and formulate an assignment for the game jams. In 2014, the theme addressed was “Improving ICT Skills”. This section presents the annual theme addressed by the JamToday Network, the common assignment to the different game jams and the main outcomes and lessons learned from the first edition of the JamToday game jams.

4.1 Improving ICT Skills: Policy context and existing initiatives

This section provides some contextual information on the policy context and existing initiatives in Europe related to the “Improving ICT skills” theme. Both at European and national levels, there is broad consensus among policy makers about the crucial importance of e-skills for Europe in the knowledge-based economy: e-skills shortages, gaps and mismatches and a digital divide will negatively affect growth, competitiveness, innovation, employment and social cohesion in Europe. As new technologies are developing rapidly, e-skills are increasingly sophisticated and need to be constantly updated. There is a critical need for individuals with creativity, innovation and higher-level conceptual and meta-cognitive skills. A recent study for the European Commission on the "international Dimension and the Impact of Globalisation" (IVI, 2014) on eSkills recently highlighted the crucial need for integrated policies as the world is confronted with a growing e-skills gap that can in turn curb economic competitiveness and recovery. The report highlights that "As part of the new global sourcing models, different skill sets are required in different regions, and new technologies keep demanding changes in the type of skills required. These new technological trends are likely to act as further drivers of increased demand for ICT practitioners over the coming years."

European policy makers have identified the development of digital skills as one of the most pressing issues to be addressed. The Europe2020 Strategy (European Commission 2010) identifies digital literacy as a key competence for the younger generation. Before that, digital skills were already supported by the eLearning initiative at the dawn of the millennium and further elaborated in the Communication on e-Skills (European Commission 2007). Recently, the lack of ICT skills has been identified by the European Digital Agenda (European Commission, 2010) as one of the seven most important obstacles to harnessing the potential of ICT. This has for example lead Policy makers to call for further innovation in the education system for smart growth in Europe (Europe 2020).

At national level, there also are very high levels of activity in the Digital Literacy domain and in the e-Skills area where the focus is on ICT practitioners and professionals rather than the population at large (Empirica 2014). A mapping of policies dealing with e-skills in the EU-28 recently found that there are some 100+ policies dealing broadly with e-skills (including in particular policies such as digital literacy/user skills and e-inclusion). Generally speaking, the report on the "international Dimension and the Impact of Globalisation" (IVI, 2014) identifies twelve key policies from the analysis of the existing policies dealing with eSkills across Europe:

- Including ICT in education reform is considered to be a key factor
- Teacher training curricula needs to include ICT
- Immigration policy reform should be implemented to attract talent
- ICT career opportunities and career paths should be strongly promoted
- Labour market monitoring is needed at national and EU level
- The uptake of the e-Competence framework should be promoted
- Member States should consider multi-stakeholder partnerships
- ICT training and educational curricula should meet labour market demand
- Up-skilling and re-skilling measures help ICT professionals to take new jobs
- Matching of jobs and ICT professional competences needs to increase

- ICT education for girls should be promoted
- Member States should create a dedicated entity to design and implement a coherent and consistent long term e-skills strategy (e.g. ICT skills sector council, national coalition etc.)

4.2 The 2014 JamToday assignment

Based on an extensive literature review and consultation with experts from the ICT and Learning sector through an Expert Advisory Group meeting held in Brussels on 28 February 2014, JamToday defined a common assignment for all the game jams. This assignment was used in all the game jams. While being specific and open at the same time the assignment aims at tackling issues that emerged from the literature review carried out by the JamToday Consortium and the consultation of thematic experts that participated in the Expert Advisory group. Moreover, the JamToday evaluation framework and selection criteria have been defined as a replicable model tailored to the annual theme. In 2014, the assignment was

> *We don't want to address learners in a vacuum. We want to address both teachers and learners.*
>
> *We don't want to address coding in a vacuum. We want to address not just the coding but also the experience and impact and in this way address meaningful coding as a way of reinforcing critical thinking.*
>
> *For some, just solving the puzzles is enough. But the fun of coding lies in solving the puzzle and by doing so, building something that works and something that gives pleasure to others.*
>
> *So, the assignment is:*
>
> *"Develop a game that stimulates teachers and learners to work together with coding logic in order to promote critical thinking, creativity and design".*

4.3 Towards applied-games for learning environments

Based on the JamToday Toolkit and the JamToday model, in 2014 game jams were successfully organized in 8 European locations from June to October 2014. In all locations, jammers worked on the common assignment presented above. The assignment was introduced to the jammers on the first day of the game jam. In total more than *200 participants* were involved in this year's edition and *47 game-based learning prototypes* were successfully developed. A wide range of participants participated in the game jams with very different profiles. The youngest participant was 5 years old and the oldest was over 60 years old.

Figure 3: Tool to build teams used by the 2014 game jam in Barcelona at ENTI/CITILAB

All game prototypes are available from the JamToday online Learning Hub. Each organizing country selected a winning game, and external experts then evaluated these games. The evaluation framework combined quantitative and qualitative data and evaluated the game prototypes on several criteria:

- Technical evaluation of the games
- Focus of the games on the assignment
- Learning sectors and transferability

The evaluation of the games found that the technical quality of the games developed was in general more than satisfying, especially considering the particular context (the game jams) in which they were developed, and the largely non-professional composition of the various development teams. The games developed did tackle the assignment proposed, and they proved to be able to foster the key skills required by the assignment. The games were tackling in general mostly the K-12 and High School sectors of learning; however, some of the games proved to be applicable for other learning sectors.

As pointed out above, the ultimate aim of applied games is the meaningful application of game-based principles in the fields of application. To reach this objective, professionals from the field of application also took part in the game jams. Furthermore, the best games were also presented to professionals from learning and training environments in regional training workshops. These workshops were organised in 7 regions to introduce the best games from the JamToday game jams and to enable educators to use educational games in their lessons to improve students' coding skills. Workshops were organised in Stuttgart, Sofia, Barcelona, Turin, Milan, Leuven and Graz.

The success of this first edition with 8 game jams organised in 7 countries shows that the JamToday Toolkit is a useful tool that has enabled partners without experience in running game jams to successfully run and attract participants. There were different approaches taken by the game jam organisers. Some partners had no previous experience in running game jams while others had been organising game jams for many years in other contexts such as the Global Game jam. Similarly, there was a great difference in the experience partners had in working with game companies. This open approach has enabled the Network to reach a large number of participants with very different profiles. While some game jams gathered professional and semi-professional participants (such as students in game design), others have gathered a mix of children and adults without necessarily having previous experience in coding or developing games. As a consequence the games developed also have very diverse identities: some are rather simple video games; others are more advanced; and others opted for analogue board games.

The analysis of the first JamToday game jams shows that there is a consensus amongst game jam organisers on the relevance of the game jam instrument as an efficient way to quickly develop and explore new solutions to a problem, raise awareness about the potential of applied game design and bring together stakeholders from different horizons with a potential to have concrete socio-economic impact. From the games developed during the game jams, some are now being developed further for the market, and elsewhere jammers decided to work together beyond the jam in local incubators. Organisers of jams where jammers with no previous experience in programming were positively impressed by the efficiency of the JamToday model, which allowed people with no programming background to develop video games from scratch.

As anticipated, involving experts and industry professionals was mentioned as one of the key factors to success, as they are particularly useful in providing contextual information related to the theme or helping teams to adjust their expectations and support them in staying aligned with the assignment. The flexible approach followed by JamToday has enabled organisations with different profiles and agendas to successfully run a game jam. The impact of the approach can be identified not only for the learning environments for which the games are developed and can be measured on other variables such as:

- Broadening the network of game jam organisers
- Peer-learning for game jam participants
- Capacity to attract people that would normally not work with games and raise awareness about the potential of applied games for people outside the gaming sector

- Capacity to trigger interest in working on new themes for game-developers or with other fields of application
- Impact on game companies that can experiment with new contexts and new themes
- Capability of the game jam to bring participants in contact with new economic actors at regional levels
- Discovery of talent and enhancing capacity
- Improving collaborative creation of applied games
- Opportunities for new collaboration for participants
- Entrepreneurial discoveries

5. Conclusions

Established in 2014, JamToday is the first European network dedicated to the organisation of game jams for applied games. Each year, JamToday tackles a thematic area and seeks to provide a replicable model that helps to maximise the impact of applied game-design for learning environments. At the core of the JamToday methodology is the organisation of game jams, offering support from planning to evaluating and transfer of game-based learning prototypes.

In 2014, more than 200 participants took part in JamToday game jams to develop close to 50 game-based prototypes on a common assignment. JamToday provides the tools to identify and attract the right stakeholders and be a platform to meaningfully bring stakeholders with different backgrounds and expertise together in co-design exercise thus fostering dialogue, mutual learning, co-creation and quick prototyping sessions.

The experience from JamToday highlighted that game jams are an effective tool to foster such cooperation, which in turn can yield changes in attitudes towards game-based learning and foster dialogue between stakeholders for the promotion and development of game-based solutions for learning environments and a way to raise awareness about the potential of applied-game design. Game jams are also a good way for people outside the game world to get an insight into game-design processes. It is precisely this transparency that JamToday has sought to foster. JamToday also provides tools to facilitate the implementation and validation of game prototypes in learning and training contexts.

The lessons learned from the first game jams will help the JamToday network to enhance the tools developed to support the organisation of game jams, which in turn can be used by new members willing to join the JamToday network. In 2015 and 2016 the themes addressed will be “adopting a healthier lifestyle” and “learning maths”.

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Beyond Power Systems Analysis: Game-Based Learning as an Instructional Alternative

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Abstract: The translation of theoretical principles into practical application exposing undergraduates to real-life situations remains a challenge. The integration of problem-based learning approaches (Albanese & Mitchell, 1993) is requisite for instilling problem-solving abilities which inform good pedagogical practices. Game-based learning presents an opportunity to provide a degree of verisimilitude (Popper, 1963). Verisimilitude refers to the appearance or semblance of truth, likelihood or probability. As an essential ingredient to ensuring that engineering undergraduates possess both technical and applied competence the introduction of "probability or likelihood" necessitates a vehicle representing a facsimile of real-world industry challenge they will face upon graduation. This case study evaluates the results of students' exposure to a serious game as an alternative approach to traditional class-based business course delivery integration into the electrical engineering programme. It further analyzes critical factors as degree of flow (Csikszentmihalyi, 1990), challenge, usability and cognitive load (Sweller, 1994) to assess participant experience when exposed to immersive environment closely resembling real work-place scenarios via the introduction of new subject matter.

Keywords: game-based learning, verisimilitude, flow, cognitive load, problem-solving

1. Introduction

To address the deficit of core business exposure of final year undergraduate engineering students within the Department of Electrical Engineering at the University of the West Indies (UWI), St Augustine, Trinidad & Tobago an existing (3) credit course on Power Systems Analysis was modified to include the use of IBM's City-One game to exposure participants to business decision-making. The game consisted of (2) distinct categories: Water/Energy & Banking/Retail requesting participants to make key decisions with regards to the development of a "smart city."

The electrical engineering programme at the University of the West Indies (UWI), St. Augustine – Trinidad & Tobago has been a core component of the institutions offerings for well over 60 years. As part of the undergraduate BSc. Electrical Engineering curriculum, seven three credit courses are delivered sequentially over a three year period as follows: two courses at level one and two and the final five at level three. Power Systems Analysis (PSA) is one of level three courses with its aims to provide students with comprehensive material about the operations and analysis of powers systems with the following expected outcome:

- Provide knowledge to students about modeling and simulation of power systems in steady or pseudo-steady states and the computational tools required to solve and analyze these models.
- Familiarize students with engineering techniques of PSA used in the industry and design of power systems.
- Familiarize students with the use of software based modern PSA tools.

PSA is delivered over a period of 30 contact hours with six hours of tutorials. Traditionally, the course lacked connections to the use of fundamental concepts aligned to effective impact on business decision-making and opportunities for practical contextualization of choices. The lecturer felt the need to integrate a component of business decision-making through substitution of one of the final assignments with a business game.

IBM's City-One Serious Game was identified as the game of preference as it embedded core course content material (i.e. design & implementation of smart grid systems).

1.1 About IBM City-One serious game

City-One is a game premised on working to build a smarter city by working with recommendations from a group of consultants across Energy, Water, Retail & Financial Services. It utilizes three satisfaction metrics to evaluate a "smarter" city:

- Inhabitants' welfare
- Business and

- Environment

Decisions related to these metrics are constructed around key process metrics, business analytics, smart grid technologies and integrated supply chain systems. The objective is to take effective decisions to make the city become smarter traking into account different factors.

The game was administered firstly in 2012, then again in 2013 and 2015 respectively with a two-fold purpose:

- Integration of a game-based learning methodology into a traditional “chalk & talk” course
- Provide an alternative approach to inculcate business thinking principles into final year undergraduate engineering students.

2. Problem identification

Engineering progammes are known for their rigor presenting many challenges to their target audience due to their complexity and highly computational nature. Modern professional engineers are expected to deal with consistent uncertainty, incomplete data and competing/conflicting demands from clients (Mills & Treagust, 2003). They require participants who possess human relation, technical competence and business acumen. As a consequence most students participating in these courses are faced with a high degree of complexity regarding subject material and the requisite analysis involved in problem-solving. Despite the challenges that aspiring engineers face in the workplace the predominant model of engineering education remains “chalk & talk”. Developments to foster student-centred learning have had relatively little impact on mainstream engineering education (Mills & Treagust, 2003).

The PSA course bears no difference to current traditional engineering teaching models requiring a high degree of complex computation utilizing MATLAB and POWERWORLD software and including two take-home exercises over an 18-24 day period, Table 1.

Table 1: PSA assessment artifacts details

Assessment Artefact	Must Pass	Weighting %	Qty
Final Written Examination	No	75	1
Computer Simulation Exercises (CSE)	No	15	3
Assignment	No	5	1
Game	No	5	1
Total		100	6

As a consequence the degree of overall participation and success rate in the PSA programme remained challenged with many students performing at or just slightly above the average. Further compounding the course’s complexity is its abstraction from practical opportunity application enabling students’ engagement in the broader perspectives of their profession such as social, environmental and economic issues. The opportunity for practical application remains a requisite yet unresolved ingredient, impacting real-world decision-making and problem-solving for graduates. A fact reinforced by (Blackwell, Bowes, Harvey, Hesketh, & Knight, 2001).

The PSA course faced three major challenges in its present format:

- Content Complexity
- Integration and relevance from a business application perspective
- Learner Engagement

According to (Tryggvason & Apelian, 2006) engineering education is at a crossroads. The rapid changes occurring in the world are resulting in a need to re-engineer engineering education solidly preparing graduates for professional roles. In its present format the PSA course meets the rigorous content expected of a 3rd year electrical engineering programme however, its teaching methodology remains essentially second half of the 20th century i.e. the creation of scientific engineers. The programme’s lack of the requisite 21st century ingredients such as people skills and innovation complementing the technical skills currently being taught and enabling competencies for information gathering and decision-making as a course of action requires much further action. Ideally what is required is an entrepreneurial engineer (Tryggvason & Apelian, 2006) who:

- Knows everything- can find information about anything quickly and knows how to evaluate and use the information

- Can do anything- understands the engineering basics to the degree that they can quickly assess what needs to be done, can acquire the tools needed and use those tools proficiently
- Works with anyone/anywhere- has the communication skills, team skills and understanding of global and current issues requisite to work effectively
- Imagines and can make imagination a reality, possesses the entrepreneurial spirit, imagination and managerial skills for need identification to come up with novel solutions and execute

The challenge remains providing this target audience (18-23yrs) barely into their adult life with the requisite competence when their own perception remains one of high proficiency (Cowan, 1998).

Given the identification of requirements for a 21st century engineer the PSA course was utilized as a starting point to overcome the three existing challenges utilizing a game-based learning (GBL) approach:

- Embrace best practice principles for continuous curricula improvement keeping the course content at the forefront of the initiative.
- Create a degree of inter-connectivity between the core underpinning of PSA and the broader business context.
- Closely examine the level of student engagement specifically as it relates to cognitive load reduction and engagement.

3. Why a game-based learning approach

3.1 Understanding game-based learning

The introduction of gaming for educational purposes has over the years grown in relevance as an educational tool. Games designed for education and problem solving focusing on illustrating the impact of specific decisions are becoming more prevalent as a source of pedagogy in higher education. (Wu, Hsaio, Wu, Lin, & Huang, 2011) provide a most concise definition of GBL "game-based learning is learning through the game, rather than learning to play the game."

GBL is characterized by such key elements as:

- Game Rules: further divided into ludis and paidea, where ludis represents games whose results are defined by a winner/loser vs. paidea whose rules do not (Gonzalo, 1999).
- Game Play: involving interaction with games through its rules, player connection, challenges and solutions.
- Game Narratives: a story constructed through a description of the sequences of fictional/non-fictional events.

Games provide a different pedagogical perspective within a higher education context. They are not a natural fit to the pedagogical landscape but represent two critical factors which need to be considered:

- They are impactful
- They are emerging as a potential source of disruption in current teaching models

Given these two factors, some attributes of games are as follows:

- Task specificity
- Ability to concentrate on the task (deep immersion)
- Task have clear goals
- They provide immediate feedback
- They provide a high degree of autonomy

The focal point of games rests in their ability to provide a degree of engagement and immersion enhancing the overall student experience (Brown, 2004). The concept of game-based-learning (GBL) exposes participants to higher levels of engagement (Annetta, 2010) representing the nexus of semi-autonomous learning, inclusive of the use of technology as a form of pedagogical praxis. (GBL) leverages the power of play to improve student learning/performance. Application of game-based learning draws upon the constructivist theory of education.

Constructivist theory is the basis for active learning, emphasized by hands-on, activity-based teaching/learning where students develop their own frame of thought (Keengwe, Kidd, & Kyei-Blankson, 2009). Drawing from the constructivist theory of education, GBL connects educational content with computer or video games and can be used in almost all subjects and skill levels. A constructivist context provides a possible answer to one of the challenges faced in the classroom with today's digital natives, i.e. how to teach learners with backgrounds different from their own (Keengwe et al., 2009).

3.2 The value of engagement - flow

The higher education curriculum within UWI requires re-engineering of its pedagogical innovativeness to improve content delivery specifically in complex subject domains given the challenges of practice. Institutionally, curriculum approaches at UWI have been predominantly traditionalist centered on academic instruction, with students as passive recipients. Students' contributions to content flexibility, delivery or its mode of gestation are minimal. To successfully engage today's students better strategies for learner retention/engagement are required. A GBL approach provided an opportunity for creation of an "engagement space" coupled with a high degree of learner autonomy. Learner autonomy refers to the capacity of the learner focusing on: supporting reflection, communication & collaboration and exploration & experimentation (Schwienhorst, 2012). This engagement approach sought to achieve a degree of flow (Csíkszentmihályi, 1990). Flow describes the rewarding, subjective, emotional state of optimal pleasure that arises when an individual is absorbed in either work or leisure activities. Central to the idea is the optimal match between skills an individual possesses and the challenges presented by the activity. The use of a GBL approach allowed the adoption of an intrinsically rewarding, immersive experience providing students with a sense of personal control, clear goals and direct/immediate feedback. Consequently, the GBL approach aspired to provide a form of course enhancement utilizing technology. Technology is forcing rapid changes in the academic landscape with academic environments continually struggling to keep up with new learning technologies as it relates to instructional delivery targeting digital natives (Prensky, 2001). The need for tools which support greater learner integration has becomes a mandatory requirement to support consistent levels of engagement amongst the student population.

3.3 Role of cognitive load

Cognitive load (CL) (Sweller, 1994) theory is a universal set of learning principles that are proven to result in efficient instructional environments as a consequence of leveraging human cognitive learning processes (Clark, Nguyen, & Sweller, 2011). The theory applies to all types of content, delivery media and all learners. The theory is evidence-based offering concrete principles which lead to very specific guidelines that all instructional professionals can implement. The value of CL in modification of the PSA curricula and integration of the business component rests in its ability to provide an opportunity for more efficient learning. The basic perquisites for PSA such as computational courses in basic calculus, differential equations, elementary matrix analysis and basic computer programming are standard. While any 3rd year undergraduate student in an engineering programme should be proficient at these courses the reality is usually quite different. As such a reductionist (an attempt/tendency to explain complex facts, entities, phenomena or structures through simplicity) methodology is required. Moreover, due to the highly technical nature of electrical engineering very little focus is placed on business decision-making so that students can explore the interrelatedness between theory and action. The use of GBL targeted primarily intrinsic (load imposed by complexity of content) and germane (load imposed by instructional activities which benefit the instructional goal). As such the game was used to balance theoretical complexity (intrinsic) with new learning (business application) and an element of fun to improve engagement. Ultimately, the desired result was to create efficient instruction by maximization of germane load since the content is relatively inflexible and manipulation of the intrinsic load is outside the control of the lecturer. The use of visual and auditory presentations through the GBL exercise sought to support learner attention/retention and reduction in the amount of information to be processes through devolution into bite size pieces. This was especially relevant given that students understood theoretical perspectives but their interrelatedness with business decision-making principles was absent.

3.4 Benefit of Verisimilitude integration

Verisimilitude (Popper, 1963) refers to the *quality or state of appearing to be true to synthesize real experiences*. Its integration into the PSA's instructional approach rests with its ability to ensure cognition, conviction and adhesion allowing for a high level of rhetoric allowing students to experience real-world possibilities within the interrelated engineering and business decision-making context. GBL allowed participants to experience a sense of their own decision-making in a real context balancing action learning and traditional theory to create the levels of analytical awareness requisite for identifying important issues and choosing appropriate actions. I.e. provide students with a sense of what could actually happen specifically when confronted with events that coincide with the "real-word possible." The game presented an opportunity to understand the impact of decisions from a purely narrative perspective but with corresponding mimetic procedures that give the narrative a referential relationship (Calame, 2012). The rational for the use of a verisimilitude approach rest with the view to challenge knowledge and the assumptions made in theory, given that theory represents conceptual tools for systematic observation and their statements do not hold real world value (Niiniluoto, 2014). As such a modified application of Popper's verisimilitude theory allowed for "truthlikeness" i.e. a representation of theories as disjunctions of constituents. Constituents are a complete theory or maximization of a possible world within a conceptual framework. As such the use of the GBL was reinforced by verisimilitude to provide a degree of approximate truth or accuracy closing the gap between theory and application. The goal being to inculcate rational inquiry into the student learning process by exploration and convergence of two approaches to ascertain some degree of truth approximation between the theoretical premise of engineering and business action.

These factors correlate positively with curricula enhancement and align to improvement of content design specifically when considered in the context of traditional course delivery. The impact-correlation factor between game-based learning and the engineering curricula lies in the increased engagement, learner retention, reduction in cognitive load and increased student participation and attendance. These represent key factors for consideration in courses such as the electrical engineering PSA module as they act as enablers for higher curricula participant engagement (Squire, 2003)

(Ashley.R, 2007) speaks to the future of games in education and frames game adoption in formal education within a problem-type taxonomy. Treating with the deconstruction of the PSA course via the introduction of game-based problem events which introduced a business perspective greatly assisted in content design and delivery. It further assisted in deciding what type(s) of interventions are appropriate for course improvement.

4. Methodology

This initiative followed an action research (Brydon-Miller, Greenwood, & Maguire, 2003) approach taking advantage of "learning by doing." The focus on integrating business decision-making through GBL was contextualized within a problem-based framework centred on creation of an opportunity to demonstrate real world decision-making processes. The action research approach provided a solid foundation for identification, analysis and improvement of current gaps in the PSA course. The research design process focused on observation of play and reflection exercises as part of a debriefing (Yasmeen, 2008). An action research methodology (plan, act, observe, reflect) ensured the required degree of methodological robustness applied to game-based learning as part of reflective and dialectical critique reinforced by collaborative resourcing (Gerald, 1983) & (Mckay, 1992). This approach also allows for further observation, diagnosis and action as it relates to investigation of the GBL phenomena and its utilization.

4.1 Implementation approach

As indicated earlier IBM City One was the game of choice. The game substituted for an existing assignment worth 5% consisting of a traditional PSA related problem-solving essay. Instead of administering the assignment on the relevance/impact of smart-grids the game sought to introduce a degree of verisimilitude through a simulated/causal approach. The game was utilized as the assignment, with students required to play and engage in a reflective discussion on both technical aspects of the game (i.e. smart-grids) such as its feasibility, challenges and implementation considerations representing the 5% as well as more general thoughts on their experience with regards to non-technical factors which might influence design decisions.

The game was installed in the computer labs providing a homogeneous environment and better control/observation of student game-play activities. A brief was provided to students which included the objectives of the game and its components. Two graduate teaching assistants (TAs) were recruited to assist with administrative aspects (lab set-up, logistical coordination of students etc.). TAs distributed briefs on the game at the beginning of the course allowing students to digest the information and ask pertinent questions. The game was played in week 6 substituting for an existing class session. The actual lab day consisted of:

- Briefing session on rules of play
- Time-frame for play/duration
- Recording keeping/tracking of final scores &
- Debriefing

The sessions was followed up with a 1.5hr discussion with students to gain deeper insights into their game-play experiences and distribution of a feedback survey via Qualtrics to be returned one week post-discussion.

5. Findings

5.1 General findings

Given that the primarily exploratory nature of this approach the receptiveness by faculty and students were quite positive. The feedback survey provided very specific information across several broad categories.

General findings were as follows:

Table 1: Game design ranking

Choice	UWI-Electrical Engineering Students - IBM Game (2012)	UWI-Electrical Engineering Students - IBM Game (2013)	UWI-Electrical Engineering Students - IBM Game (2015)	Total
Extremely user friendly	8	6	5	19
User friendly	33	20	13	66
Somewhat user friendly	8	3	4	15
Not user friendly		1		1
Neutral	1			1

Approximately 107 students participated over the three year period with an overall positive ranking of the game 80% approximately indicating the game's user friendliness. The mean difference over the 3 year period was approximately 1.34 with a standard deviation of only .31 between respondents. Hence, the rankings remained positive despite reduction in class
size over the 3 year period.

Table 2: Game navigation

Choice	UWI-Electrical Engineering Students - IBM Game (2012)	UWI-Electrical Engineering Students - IBM Game (2013)	UWI-Electrical Engineering Students - IBM Game (2015)
Yes	93.88%	93.33%	90.91%
No	6.12%	6.67%	9.09%

Reviews of the game remained consistently positive as students continuously rated the navigation features with a 90% range. Mean navigation scores for the period varied little over the three year period averaging only a 1.06% difference for the overall initiative.

Table 3: Least Liked aspects of game

Choice	UWI-Electrical Engineering Students - IBM Game (2012)	UWI-Electrical Engineering Students - IBM Game (2013)	UWI-Electrical Engineering Students - IBM Game (2015)
Music/Graphics	18.00%	16.67%	13.64%
Duration	20.00%	43.33%	31.82%
Game Content	4.00%	3.33%	9.09%
Game Navigation	18.00%	16.67%	4.55%

Table 4: Most liked aspect of the game

Choice	UWI-Electrical Engineering Students - IBM Game (2012)	UWI-Electrical Engineering Students - IBM Game (2013)	UWI-Electrical Engineering Students - IBM Game (2015)
User Interface	10.00%	13.33%	13.64%
Music/Graphics	4.00%	10.00%	13.64%
Interactivity	28.00%	23.33%	31.82%
Game Content	56.00%	53.33%	36.36%
Game Duration	2.00%		
Game Navigation			4.55%

Overall, the most liked aspect of the game was the content. 2015 scores saw a decrease in the content as the most liked aspects at 36.8% with interactivity 31.82% close behind. The three year average mean across all responses was 3.20 with a standard deviation in responses of 1.1 for the same period.

Table 5: Components new to students

Choice	UWI-Electrical Engineering Students - IBM Game (2012)	UWI-Electrical Engineering Students - IBM Game (2013)	UWI-Electrical Engineering Students - IBM Game (2015)
Energy		6.90%	19.05%
Water	2.08%	6.90%	4.76%
Retail	39.58%	24.14%	19.05%
Banking	41.67%	41.38%	33.33%
All of the above	6.25%	20.69%	19.05%
Unsure	2.08%		
None	8.33%		4.76%

The introduction of new concepts to students in retail and banking were the most unfamiliar as engineering students had no prior exposure to these subject domains.

Table 6: Component requiring greatest mental effort

Choice	UWI-Electrical Engineering Students - IBM Game (2012)	UWI-Electrical Engineering Students - IBM Game (2013)	UWI-Electrical Engineering Students - IBM Game (2015)
Energy	37.50%	58.62%	27.27%
Water	2.08%	10.34%	4.55%
Retail	18.75%	10.34%	9.09%
Banking	10.42%	17.24%	50.00%
All of the above	22.92%		
Unsure	2.08%		4.55%
None	6.25%	3.45%	4.55%

Interestingly, the responses for this question were expected to be in line with those of Table 5, given students' challenge with the banking and retail components. However, it was actually the energy component related to implementation of the smart-grid that challenged students most. Over the three years period the energy component averaged 41% by respondents as it related togreatest mental effort. Students attributed the effort to both a lack of application of theoretical aspects of PSA to real world situations.

Table 7: Ranking degree of mental effort

UWI-Electrical Engineering Students - IBM Game (2012)							
#	Answer	1	2	3	4	Responses	Mean
1	Energy	13	6	4	21	44	2.75
2	Water	15	17	10	2	44	1.977273
3	Retail	3	14	17	10	44	2.772727
4	Banking	10	9	15	12	46	2.630435
	Total	41	46	46	45		
UWI-Electrical Engineering Students - IBM Game (2013)							
#	Answer	1	2	3	4	Responses	Mean
1	Energy	7	2	4	13	26	2.884615
2	Water	11	6	5	2	24	1.916667
3	Retail	2	11	9	1	23	2.391304
4	Banking	4	7	10	8	29	2.758621
	Total	24	26	28	24		
UWI-Electrical Engineering Students - IBM Game (2015)							
#	Answer	1	2	3	4	Responses	Mean
1	Energy	5	7	3	2	17	2.117647
2	Water	3	9	3	0	15	2
3	Retail	3	4	9	2	18	2.555556
4	Banking	2	0	5	12	19	3.421053
	Total	13	20	20	16		

Finally, students were asked to rank each area of the game using a Likert Scale ranging from 1-Not difficult to 4-very difficult. Table 7, illustrates the results. 2015 was the only period where the degree of difficulty saw reductions. This may be partly attributable to revisions in the curricula based on feedback from the prior game-play feedback.

5.2 GBL specific findings

Based on the game-play exercise the above findings illustrate general feedback. However, the subsequent discussion(s) with students provided deeper insights as it related to the student learning experiences as follows:

- **Benefits of game-based learning experience**: Students indicated the benefits of the game through the use of such key words as: *problem contextualization, consequences, insights, choice vs. impact and relatedness* as key learnings. Their general consensus was that unlike readings in textbook the play experience was "real" allowing them the opportunity to see the consequences of their actions in real-time based on various options chosen to resolve issues regarding creation of a smart city. Exposure to options that included factors outside the technical such as quality of life held extreme relevance to the participants. Furthermore, the students commented heavily on the verisimilitude component indicating that the realness of the choices and subsequent consequences forced them to reconstruct their technically biased engineering views and lean towards more holistic value-driven solutions taking into consideration environmental and social factors.
- **Causality & Relationships**: A second specific GBL finding was the impact on students understanding of the relationship between causality and decisions. Students articulated how such factors such as cost/upgrades in infrastructure became clearer from the perspective of how they affected consumers, population migration patterns and the overall economy within a city. The relationship between technical feasibility of engineering projects and the social costs as it related to such concepts as happiness, community and other

intrinsic benefits "tied" back to infrastructural development context and the development of reliable systems. Furthermore, they indicated the requirement of careful consideration and planning of new engineering ventures to ensure that all citizens benefitted equally.

- **Economic reality**: A 3rd critical observation by students was the reality that engineering design decisions are not created in a vacuum and that they are impacted by cost of capital as well as general operational decisions as it relates to opportunity-cost of other investments unrelated to the distribution and management of electricity consumption. While initially most found utilizing smart-grids as a "cool" technology approach they all agreed that good engineering decisions are necessitated by proper financial decision-making and heavily influenced by consumer affordability. Theoretical aspects of PSA that were challenged within real world situation as the interrelatedness of cost issues required other considerations such as geography, extensive feasibility studies and their delivery of customer value.
- **Facilitative approach**: Students asked the question why such an activity could not be utilized for the entire course, as it proved more engagement than traditional classroom lectures. They indicated that they were never bored during the play or subsequent discussion and expressed their ability to better articulate their understanding of PSA related material, specifically smart-grid technologies after the exercise. Moreover, they utilized such terms as *enlightened, better thinking and knowledgeable* to describe approaches which included them in the learning process.

6. Conclusion

The relevance of GBL in Electrical Engineering benefits from a closer linkages to the theory of play and learner identity. Important components of learner-centered models are the consideration of learning characteristic, interspersed with sub-variable such as learning styles, abilities and other antecedents that make each learner unique (Gollnick & Chinn, 2002). The fact that students felt *included* augurs well for this pilot initiative.

The approach provided faculty with some key considerations such as:

- How to better integrate external non-technical related factors into course delivery to enrich discussions.
- The need to be more holistic regarding articulation of highly complex technical subject matter through demonstration of causal relationships impacting technical implementation.
- The need to re-orient traditional approaches to subject delivery, allowing students to be active vs. passive participants.
- The need to closely examine not only GBL approaches in the classroom but those premised on inquiry, experimentation, collaboration and experiences engaging students in a manner which bears relevance to these tenets enhanced by both the process of play and the encouragement of discovery.

The use of GBL approach contrasts with the traditional teacher-led. Generally, students have limited or no control remaining passive recipients diminishing the valuable contribution they can make to learner-centered approaches. discover patterns, concepts and other relevant data (Squire, 2003) . There is an underlying Video games support student exploration through micro-worlds or as construction tools consistent with emerging paradigms of learning (Papert, 1980).

As such faculty must provide opportunities for trial & error and experimentation as a fundamental component for hypothesis testing (Narode et al., 1987). The relevance of using a GBL approach attests to the availability of alternatives to present best effort teaching where students memorize theory through rote approaches without actually experiences of the process. Play is an integral part of the learning process and its use can improve their skills through coaching and practice. As such game-based learning approaches can be a conscious attempt to step away from rigorous Socratic methodologies. The choice of games as a means of reinforcing and expanding conceptual thinking within the PSA course presents an opportunity students to understand not just how smart-grids work in a real world situation but that such engineering technology decisions are heavily influenced by economic, social and other factors that may make such technologies either unattractive or costly in some societies.

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Creativity and Playfulness: Producing Games as a Pedagogical Strategy

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Abstract: This article explores how student behavior and interactions change when teachers use "producing games" as a primary pedagogical strategy (Papert, 1980; Ejsing-Duun and Karoff, 2014). Based on student and teacher actions and responses, as well as on students' production—observed during fieldwork—this paper emphasizes the importance of understanding how students explore creativity and playfulness while producing in learning situations. This paper is based on a large research project called "Children as Learning Designers in a Digital School (2013–2015)," funded by Denmark's Ministry of Education. The study includes fieldwork in five Danish public schools, involving about 500 students, and it is based on six interventions in the first, second, fifth, sixth, and tenth grades. The article's empirical data consist of observations, participatory observation, and productions students created during the interventions. This paper presents an analysis of how students are creative and playful while producing learning material as games, during two interventions in the research project. The study is based on a specific understanding of the creativity (Boden, 2004) and playfulness (Karoff, 2013) that occur in learning situations. We want to approach creativity and playfulness as new ways of playing it safe when using material, through six areas of change that inform "how today's kids play and learn, and, more generally, how they see themselves, relate to others, dwell in place, and treat things" (Ackermann, 2013, p. 119). As a result, this paper contributes to the field by analyzing and discussing how educators deal with children's production processes in a school setting and how teachers can conceptualize and nurture play and creativity as drivers for learning. We further argue that playfulness is necessary for creativity to occur. From this point of view, understanding how learning activities can support creativity—an essential twenty-first century skill—becomes more accessible.

Keywords: production of games, creativity, playing, learning.

1. Introduction

This paper addresses the question of how creativity and playfulness inform and qualify learning processes in schools. More specifically, it explores how student behavior and interactions move toward creativity and playfulness when teachers use "producing games" with digital tools as a primary pedagogical strategy (Papert, 1980; Ejsing-Duun and Karoff, 2014). Based on student and teacher actions and responses, as well as on students' production—observed during fieldwork—the paper's goal is to emphasize the importance of understanding how students can explore playfully and be creative while producing in learning situations and how teachers can facilitate this process.

Production as a pedagogical strategy shows good learning results. Previous research has elucidated how children learn through production (Papert, 1980). Here, the focus is on how teachers can frame production as a way to work toward learning objectives by creating an environment that allows children to explore a subject matter (Papert, 1980). Cebeci and Tekdal (2006) have also shown how production has a positive learning potential when young people are making podcasts about relevant academic subjects. Students need to be actively engaged in creating products that are personally meaningful to themselves and others. Kress (2010) points out that the abstract aspects of teaching become tangible through different materialities. When producing games, students translate abstract aspects into tangible and interactive dynamics in environments that, if carefully framed, allow students to explore the subject matter through meaningful productions. Making games is not a new idea in education. However, according to Kafai (2006, p. 36), "Far fewer people have sought to turn the tables: by making games for learning instead of playing games for learning."

Our contribution to this approach is to analyze how Danish children work creatively and playfully with digital game production in a math setting. Games are particularly relevant to achieving math objectives since they are state machines, and making these requires understanding a variety of mathematical capabilities, such as speed, algebra, calculations, and geometrical shapes.

Creativity (Boden, 2004) and playfulness (Karoff, 2013) occurred in this study's observed learning situations. By introducing six dimensions that inform how children play, learn, and create, based on Ackermann's (2013) work, we sought to explore how students use materials and design processes to explore. As a result, this paper's main contribution is to show how students can be creative in various ways when extracting knowledge from game experiences and information on game genres in schools. Furthermore, we seek to challenge the common understanding of creativity as "something totally new created out of nothing." Instead, we urge teachers to frame and embrace the disruptions and necessary copying that allow children to be productive and, sometimes, even creative.

The next section introduces the research context. Section three presents the theoretical points of departure, while section four analyzes a number of learning situations that arose during our empirical research. Section five discusses the concepts of creativity and playfulness in the context of learning.

2. Research context

This paper is based on a large research project called "Children as Learning Designers in a Digital School (2013–2015)," funded by Denmark's Ministry of Education. This empirical research consists of fieldwork in five Danish public schools, involving about 500 students and 30 teachers, and it is based on six interventions in the first, second, fifth, sixth, and tenth grades. The schools were chosen from a pool of candidates to guarantee geographical and socioeconomic dispersion (Levinsen et al., 2014). The project explores the area of students' production and involvement, and, more specifically: 1) how students' digital production affects learning processes and the quality of learning results regarding subjects and transdisciplines and 2) how information and communications technologies that allow students to act as designers of their own learning practice in terms of form, framing, and content affect their learning, engagement, and motivation.

Due to the project's complex nature, a mixed methods approach was used. In their research, Johnson and Onwuegbuzie (2014) sought to overcome incompatible findings within a complex field. This, in turn, has led us to follow a strategy linking fieldwork inspired by ethnography and design-based research that emphasizes experiments and collaboration with practitioners (for a further elaboration of this methodology in Levinsen et al., 2014, see also Magnussen and Sørensen, 2010 and Cobb et al., 2003). As Johnson and Onwuegbuzie (2014, p. 16) suggest, the "Bottom line is that research approaches should be mixed in ways that offer the best opportunities for answering important research questions." The present study's empirical data consist of observations, participatory observation, and productions created by students during the research project. In this paper, we focus on two significant situations to illustrate a tendency in our observations, which are both presented in the following two subsections.

2.1 "Did you make this yourself?"

This example is taken from a mathematics intervention in which children in fifth grade (approximately 11 years old) were instructed to program games using iPads and the software application Hopscotch. The children were extremely engaged in creating good games, and, thus, they worked intensely on their products. They asked for extra lessons on mathematical subjects relevant to their games. They also assessed each other's products throughout the project (Misfeldt and Ejsing-Duun, 2015).

Simon is a student for whom math is hard. From the beginning, he failed to complete the tutorial—a sequence of tasks designed by the teacher that introduced students to programming with Hopscotch. However, he was highly engaged in the process of making a game. In the morning on the project's third day, he found the teacher before class had started to show her his progress. She looked at the game that he had made and asked him whether he had made it himself. He replied that he indeed had developed it himself. She inquired about several features of the game, and he had difficulty explaining how they had been made. He continued to work on the game throughout the next period. As he uploaded his finished game, an icon indicated that he had retrieved a coded game from the Hopscotch community and remixed it. In the end, as other students presented their games, he followed their information with interest and then presented his own game. After he had received feedback on the game, he continued tweaking it in terms of speed and points awarded and so on. Once the project was finished, the teacher emphasized Simon's motivation as a particular success and benefit. He was captivated by the process, and he kept working with the subject matter. He did not ask for much help but worked anyway. She pointed out that he has academic difficulties and, normally, has a hard time following lessons and presenting anything to the class. Without doubt, Simon felt ownership—and was proud—of his game.

2.2 "Are you fooling around?"

This example is taken from a mathematics intervention with children in first grade (approximately eight years old). The children were introduced to the program Geogebra, using computers. The assignment was to create a shape using this mathematical tool. Afterward, the game called for the children to exchange shapes with their classmates and imitate another shape. Oliver is a boy that often goes his own way. In the beginning of the intervention, he refused to use Geogebra and, instead, drew his shapes in Paint (a Microsoft program). In the second week, he used both programs, still preferring Paint and often running both programs at the same time. However, he did draw a mouse in Geogebra, using shapes of circles in different sizes. The teacher told him to use Geogebra for his assignment, and, thereafter, he closed Paint or immediately switched to Geogebra whenever the teacher came near. In the end, as other students evaluated their assignment, he changed his mouse picture, drawing on top of what he had already made and, instead of evaluating it, redesigned the figure. Contrary to his classmates, who all did almost the same green star with blue corners, Oliver apparently needed to play around continuously with the shapes and tool's possibilities. The only way to do that was to avoid attracting the teacher's attention and do something different as compared to the others.

3. Creativity

According to Boden (2004) creativity can have three forms, none of which creates something out of nothing. The three forms of creativity relate to the subject matter—in Boden's words, the "conceptual space"—in three different ways. The first form is *combinatorial* creativity, which exploits shared conceptual structures to create analogies or metaphors. As an example, Boden mentions how a journalist might compare a politician with an animal, creating a conceptual pathway between the two. The process, thus, is guided by associative forms. In the game production, the material of game knowledge is used when relating to the production process as a metaphor for the subject matter. The second form, *explorative* creativity, relies on culturally accepted styles of thinking (i.e., artistic genres). This conceptual space is restrained by a set of generative rules and is explored when being creative in an explorative manner. When producing games, players need to explore the rules' structure throughout the game production, since it has to be playable. The last kind of creativity implies that this conceptual space is altered altogether. This is what Boden (2004) calls *transformative* creativity. As she says:

> *A given style of thinking, no less than a road system, can render certain thoughts impossible—which is to say unthinkable. The difference, as remarked above, is that thinking styles can be changed—sometimes, in a twinkling of an eye. (p. 6)*

To combine, explore, and transform are all essential ways in which creativity can happen, according to Boden. Indeed, Ackermann (2013) has seen these modes of practice among children growing up in the digital age. This author suggests six areas of change in how children today combine, explore, and transform.

3.1 Creative ways of being productive

In her paper "Growing up in the Digital Age: Areas of Change," Ackermann (2013) identifies six areas of change that appear to inform how kids currently play and learn and, more generally, how they treat things, see themselves, dwell in places, and relate to others. In our research, we found these areas inspiring as a framework for understanding production and creativity, not only as something children do but also as ways in which they do it. In the following discussion, we present Ackermann's (2013) six areas.

According to Ackermann, *sharism* is the first dimension characterizing today's children. They share even before they think of the finished state of their productions, not keeping things to themselves. *Fluid selves* is another aspect, where children explore different versions of themselves through multiple digital, virtual, and physical realms. *Crossing borders* is the third dimension. Ackermann (2013) points out that children move between worlds and urge others to cross both cultural and geographical borders. The fourth area of contemporary children's renewed approach to the world is the *literacy* dimension, in which children have new ways of expressing their experiences. They manage to blend text, sounds, and images, and, often, they borrow from those who inspire them. They invent new genres of writing by remixing, repurposing, and reconfiguring. As the fifth area, Ackermann (2013) mentions *a culture of gaming* or *"simuling*," which she uses to challenge the myth of gaming as escaping from reality. She states (p. 125):

> *Games, like play, are more like a vacation. They offer a voie royale into the realm of "altered possibilities" which allow returning to "real life" better prepared, refreshed, stronger . . . Kids use fantasy not to get out of but into the world. They make up fictions, or dramatize everyday events,*

> *in order to de-dramatize the sometimes hard-to-handle reality. Intelligence itself, to Piaget, is about establishing a dialog between what is and what could be!*

Simuling indicates a creation of an alternative world that is true and believable in its own right, in contrast to simulating, which implies pure reproduction. Ackerman´s point is that children today use the digital tools that they are presented with, or already have, to try out playful exploration in ways rarely possible with pre-digital tools. These children expect immediate feedback and use these tools to "simule" various ways of doing.

Tinkering, in Ackermann´s (2013, p. 126) perception, is exploring and extending the understanding of technology or situations through using and "making things 'do things'" and this is her last, characteristic way children today create—as *bricoleurs*, *makers*, *hackers*, and *hobbyists*. By trying things out, mixing things, and mending things together, they explore the possibilities of the world through what they create together. Through an iterative process of tweaking things, they empower their creations. The core point here is that they act before they think—or rather, they think while acting.

3.2 Playfulness in creative processes

Playfulness, in our understanding, is related to a way of being, in which goals and usefulness are not always at the center of activities (Karoff, 2013). Ackermann (2014, p. 1) addresses being playful in creative processes as a necessary aspect since "'coming at things obliquely'—through suspension of disbelief (pretense), artful détournement (displacements), and playful exaggeration (looking at things from unusual angles)—allows [one] to break loose from the habitual" To reach the stage in which one combines aspects normally not associated, explores the unknown and the known in fresh ways, or even transforms the area of interest, one needs to break habits and, sometimes, even perform what appear to be useless activities. Transgressing boundaries in playfulness is a driver for practices of change—and thus for creativity. These processes should not be tamed because, as Ackermann (2014, p. 8) suggests:

> *[B]eyond our rational mind's temptation to plan ahead and to stick to the plan (unless proven wrong or irrevocably cornered), and the blind maker's insight-less errings, the playful wanderer enchants us through his own wondrous musings. S/he knows to look at things obliquely, cares to see what others don't, and uses his/her intelligent hand—and connection to the materials—to bring forth the unexpected.*

This approach means that creators need to relate to the conceptual space within their interests without following a plan toward predefined objectives.

4. Analysis

Based on our study, we present the following important findings. First, "copying" material and reworking premade material are important aspects of creative production that can lead to learning. Second, an important part of creativity often is exploring and trying things out in a playful—even foolish way—without any specific goal in the quite near future.

4.1 Copy-cat or innovator?

Creative exploration, frequently, is based on a close imitation of something children already know extremely well, building upon existing knowledge and something already produced, which is often mistaken for copying. When Simon made a game by using the programming app Hopscotch, he downloaded an existing game and tweaked the codes and graphics: he hacked the game as a bricoleur and took literacy beyond print, as he managed to navigate the game's digital layers (Ackermann, 2013). He took the initiative to present his work to his teacher and, thus, shared it without paying attention to whether it was finished (Ackermann, 2013). While hacking the game, he was simuling a creation of an alternative world, which implies the faithful reproduction of the original—in this case, an attempt to mimic an existing game (Ackermann, 2013).

Being a student who is challenged by math, Simon would probably have been lost in the rather complex process of learning to program and invent a game from scratch, had the teacher insisted that this was required. However, Simon was engaged in changing variables and observing how values affect speed, positions, and geometrical shapes—all of which were matters relevant to the subject at hand, the conceptual space. Simon might not be an innovator, since he did not combine areas of knowledge or transform the conceptual space, but he worked creatively, exploring the field of interest and rehearsing and applying his knowledge of math. He explored literacies beyond print as he reconfigured the game code that he had "borrowed," and he hacked the game through an iterative process. He also sought the opportunity to explore the area even further as he shared it with the teacher, without thinking about what stage his work had reached.

Simon is not the only student who took a premade game as the point of departure for programming with Hopscotch. The data contain more examples of students who tweaked previously made games and applied pre-programmed blocks to their game. In this way, Hopscotch enables differentiation. This was made more challenging by the teacher, who prompted the students to present their games to the class. In the presentations, she pushed the entire class to explain features of each game, and then she had each student who had designed a game unpack how he or she had actually made it. In addition, the teacher challenged the class to find ways to improve their games and to explain how to do this. Through this process, the teacher kept focusing on the conceptual space in which students inquire about and explore through their design processes—namely, algebra, variables, and algorithms. She thereby facilitated negotiations of their productions that related these to learning goals (Ejsing-Duun et al., 2013).

4.2 Destructive or disruptive?

Furthermore, in Oliver's class, imitation and copying seemed the main way to produce shapes, but Oliver did something else. While Oliver was trying the Geogebra program without a specific goal, he drew a funny mouse, coming up with a story and telling it to a friend, within just 10 minutes. By analyzing the situation using the concepts of sharism and tinkering bricoleurs (Ackermann, 2013), an interesting observation is the ways "messing around" with the digital tool facilitates creative and playful behavior (Itu et al., 2009). This is a piece from the field notes:

> *Oliver opens Geogebra. His teacher has given him an assignment. He must draw a figure. Afterwards, he must give his figure assignment to a classmate. His classmate, then, must be able to make the same figure. Oliver makes a circle, he draws two lines across, some ears of two other circles, and, now, he has a mouse. He moves the lines within the mouse and talks with a mousy voice. Oliver laughs, he turns to Ida-Marie, the girl next to him. "Look," he says. He modifies his voice into a mouse voice, as he moves the two lines up and down, and it looks like a talking mouse. Ida-Marie is listening to the story, and Oliver says that his mouse is moving toward a dangerous mission. Ida-Marie laughs. Oliver continues to move the lines faster and faster, and the mouse eventually shouts very loudly.*

Oliver did not know the program or digital tool extremely well, since he preferred Paint, as mentioned previously. However, in this situation, he messed around with the features, trying things out and drawing a mouse using circle shapes. He was not at all tuned into the assignment's goal, but, instead, his practices were explorative, ending up in a story told to his friend. In other words, they were playful. According to Ackermann's (2013) concept of "tinkering," Oliver let the tool guide him, playing with features and possibilities as he messed around with the program. Neither the story nor the drawing were planned beforehand. Instead, Oliver was developing both while creating them, and, while he was doing this, he shared them. As Ackermann (2013) points out in her definition of sharism, sharing is the center of accomplishments, and Ida-Marie became Oliver's audience, as her laughs made the lines move even faster.

Fooling around with digital tools is a well-established practice in classes, while introducing something new to students' production processes. The data include several examples of students tinkering and fooling around while thinking. Teachers' ideas of learning practices are challenged by this type of creativity, primarily because the activity's goal is blurred. As Karoff (2013) mentions, this is quite distinctive to playfulness, and, using Ackermann's (2014) idea of looking at things obliquely, Oliver's practices seem to be driven by this process. He brought something unexpected to life, in connection to the material with which he was working. By introducing his classmate Ida-Marie to his unexpected exploration, he underlined the importance of sharing creative unexpectedness with others in order for the process to remain meaningful. In this specific case, the teacher was constantly keeping an eye on him, making sure that he did what he was supposed to do. She understood his fooling around as being destructive and not heading toward the planned goal.

5. Discussion

In our study of several schools and teachers, a recurring conception was that children often are not very creative. Many teachers expressed the worry that if teachers showed students an example of a premade product, the students would make a variation of just that. As Ackermann (2013, p. 125) writes:

> *A big problem among educators today is to come to grips with what they view as "plagiarism": students' tendencies to pick-up and pass-on readymade imports that have not been "massaged" long enough, or mindfully engaged.*

Some teachers in our observations seemed to evaluate creativity as inventing something "new" and previously unseen, which depends on the product, not the process. Another reoccurring idea was that being creative is to find new and smart ways to solve specific problems related to educational objectives.

In order to prevent aimless copying of other people's work or purposelessly goofing around, the educators in this study made different suggestions. In planning interventions, some teachers considered not showing the children any examples to prompt more unique solutions. To prevent students from goofing around and keep students on track, another suggestion was to have them make a plan from the outset. Hence, being not goal oriented was often understood by teachers as being disruptive. Another idea repeated was that good products require early analysis and planning.

However, some teachers, such as the math teacher who planned the Hopscotch game programming intervention, allowed students to find their own path after the initial tutorial. This is particularly a good idea when students are unfamiliar with tools, as was the case in the two situations analyzed in this paper. The tutorial was designed to ensure that students were presented with the tool's features and that students related to the conceptual space in the same way that the tutorial's tasks related to this. The students could then fool around with the tools, as shown in Oliver's story, trying out their features by copying and remixing content, as Simon did, to discover the tool's limitations and possibilities.

We argue that learning activities with digital tools that allow playfulness can support creativity—an essential twenty-first century skill. However, allowing students to fool around and embracing copying could be a road that leads nowhere or that is even directly destructive. This is a challenge within school systems that are increasingly goal-oriented. Teachers need to be alert to situations that emerge, to relate them to the conceptual space whenever possible, or, even better, to teach students to do so themselves. However, learning need not be only linked to a specific, narrow curriculum. When Simon messed around with the pre-programmed game, he was learning about games, about genres, about programming, about presenting, and so on. However, if teachers want their classes to learn about algebra as a group, then they should not develop objectives but rather formulate criteria that could guide the "messing around" and thus encourage exploration and combinations of materials.

The teachers' task is to maintain the students' focus on an examination of the conceptual space and to motivate the children to explore the subject matter continuously, understanding it by combining knowledge fields or even transforming their understanding of it. The children do this by qualifying and refining their products. As Ackermann (2013, p. 121) points out, "Digital natives are known for their launching of half-baked ideas and creations." For these "half-baked" ideas to be qualified further, the teachers' role is to provide time and space for continuous refinements. Thus, teachers cannot merely give students a task, send them into production mode with possible supervision, and evaluate products at the end. On the contrary, working in an iterative process has proven to be highly efficient, in which teachers and students have time-outs during the class in which they assemble and re-evaluate students' productions in their current stage in relation to the conceptual space, identifying criteria for the ongoing production together. As Sørensen and Levinsen (2014, p. 7) point out:

> *Ongoing evaluations with feedback and/or feed-forward can be used as short time-outs, where students and/or the teacher show and tell something that others can learn from, for example, when students have found out how to animate a graphic element.*

Throughout this ongoing evaluation and production process, teachers need to remain aware of what students are combining, exploring, and transforming and how this relates to the conceptual space. The challenge is to inquire about the students' intentions behind "messing around" and bring these into the conceptual space—or, if unrelated, dismiss them as such. Through this inquiry, teachers qualify the children's creativity in relation to the conceptual space, and, in connection to this space, make students refine their work, not only once, but again and again.

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Enhancement and Assessment of Engineering Soft Skills in a Game-Based Learning Environment

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Abstract: Engineering education literature shares a consensual vision of the importance of soft skills for every workplace. Despite of the growing demand for graduates with high EQ (Emotional Intelligence Quotient), one of the main challenges of the industry is the lack of soft skills, in particular, communication and negotiation skills, problem-solving skills, interpersonal skills, as well as critical and creative thinking skills. This paper investigates the enhancement of skills in a game-based learning environment, which was specifically designed to develop both hard (technical) and soft (personal) skills of engineering students through hands on experiences and observations. The acquired data is gathered using data triangulation, and it consists of self-assessments, observations, questionnaires and technical measurements. Preliminary results indicate that the environment has a significant impact on soft skill development, and show a correlation between soft-skill development and the level of motivation and self-evaluation.

Keywords: evaluation, game-based learning, hard skills, motivation, soft skills

1. Introduction

Sustainable engineering is a conceptual and practical challenge to all engineering disciplines. The idea of ‘‘sustainable engineering’’ is both powerful and challenging. It recognizes that appropriately designed products, technology systems, and services, and thus good engineering, are critical to better environmental and social performance across a globalizing economy. But it is one thing to appreciate the power of an abstract concept and entirely another to reduce it to a rigorous framework, a toolbox of methods, and sets of metrics so that it can be applied by professionals and taught to engineering students (Allenby et al., 2009). Factors such as technological advancements, the need to solve problems quickly, the ability to consider open-ended problems and to cope well under information overload put engineers under unfamiliar pressure. The only way to cope with this pressure efficiently is having the ability to combine the hard skills acquired during tertiary education and the soft skills that support handling tense situations and emotional and industrial challenges. Soft skills are arguably needed for everyday life as much as they are useful in the workplace; these are skills involved when staff members communicate and interact with each other, cooperate to achieve set tasks, and when they engage in dialogues to provide feedback, solve problems and resolve work-related issues (Rainsbury et al., 2002). While soft skill development is clearly on the agenda of engineering educators, lectures nurturing soft skill development usually take place separately from hard technical lectures – during small seminars or field trips. The purpose of this paper is to introduce a game-based, learning by doing environment, where engineering students apply and develop both hard and soft skills in the frame of a formal lecture. The following chapters outline the (2) recent changes in industrial needs and engineering education, the (3) role and benefits of hands on activities, introduce the (4) developed and studied learning environment, and (5) present its assessment and evaluation methodology. In the final chapter, (6) we conclude and present the future aspects of the research.

2. The evolution of engineering education and the emergence of the soft skill era

The objective of engineering education is to educate students who are “ready to engineer,” that is, broadly prepared with the pre-professional skills of engineering, and deeply knowledgeable of the technical fundamentals (Crawley et al., 2007). Responding to mass demand has driven many of the key transformations of the past decades of engineering education. This expansion has been driven by the shift to post-industrial economies, the rise of service industries and the knowledge economy. Over the past decades, there has been a steady stream of reports and papers urging the higher education sector to take soft, transferable and employability skills into the heart of students' learning experience. Those reports have come from governments, from the industry, and to some extent from higher education practitioners themselves. The catalyst of urging changes in engineering education was the fact that contemporary workplaces require more adaptive, more versatile and widely skilled engineering professionals. Modern engineers are not only engaged in all phases of the lifecycle of products, processes and systems that range from the simple to the incredibly complex; but they also have to meet a need of a member of society. Modern engineers design products, processes, and systems that incorporate technology (Crawley et al., 2007). They work in teams when they conceive, design and implement a product, process, or system. Teams are often geographically distributed and international. Engineers exchange thoughts, ideas, data and drawings, elements and devices with others around the work site and around the world. They capture the tacit knowledge of a system's design and implementation so that it can be revised and upgraded in the future. Good engineers work in teams and communicate effectively, while always exercising personal creativity and responsibility (Crawley et al., 2007). The emergence of the knowledge economy, the need for both technical and interpersonal skills and the rapidly changing industrial environment has changed the landscape of engineering profession, while - despite of several efforts in the higher educational sector -, curricula and teaching styles in most higher educational institutions remained practically unchanged.

Yahya et al. (2011) found that teaching and learning approaches such as problem-based learning and student-centered learning should be more implemented because these approaches allow students to have sufficient platforms to develop their soft skills as they participate actively in the learning process. Based on other research done by Yasmin et al. (2012), it has been proposed that additional soft skills are required by the undergraduates in order to face the challenges of the competitive job market. According to a research done by Ong et al. (2003), other empirical studies generally work on the assumption that learning and practicing soft skills is largely a top-down approach based on a given inventory of skills that must be acquired by tertiary students.

3. Hands-on activities in engineering education

When the winds of change have reached the engineering educator sector in the 1980's, there have been several debates on what educational methodology educators should apply to reach the desired learning outcomes. Relatively new theories like Papert's Constructionism, Kolb's Experiential Learning or McMaster University Medical School's Problem based learning was facing with traditional, teacher-centered instruction. While numerous teachers and educators were and are aware of the benefits of learning by doing and learning through play, curriculum design and evaluation processes require more attention, planning and considerably more work from the teacher's side when applying alternate approaches, than as it takes for traditional teaching styles. Under the approach used at the vast majority of universities, the teachers (or committees of teachers and administrators) are expected to decide what learning objectives are best for students, what learning tasks must be done and when, and what feedback students should be provided with (Gee, 2003). Unfortunately, objectives are seldom made explicit in universities, tasks are often of little interest to students, feedback focuses on content (facts) rather than skills, and application is seldom addressed. Motivation is based on extrinsic rewards and punishments in a competitive but still not challenging environment (Gee, 2004). According to Nonaka, orders and instructions do not foster the high degree of personal commitment on which effective knowledge creation depends (Nonaka, 1991). While teacher-centered education is still the most widely applied teaching method in tertiary education, people find learning very difficult when all they have is a definition that describes what a word means. Researchers suggest, that people only really know what a word means when they can connect them to the experiences they refer to (Glenberg, 1997). This connection gives words situated meanings, not just verbal ones. Games and hands on experiences not only situate the meanings of words in terms of the actions, images and dialogues they relate to, but they present them in action even before the word itself it taught.

4. Learning by doing modeling of manufacturing processes

Games provide an opportunity to learn through experiences and repetition (with variations), and they challenge the users again. This cycle is called "Cycle of Expertise" (Bereiter & Scardamalia, 1993) and it is the way anyone can become an expert at anything worth being an expert of. Expertise is formed in any area by repeated cycles of learners practicing skills until they are nearly automatic, then having those skills fail in ways that cause the learners to have to think again and learn anew. Then they practice this new skill set to an automatic level of mastery only to see it, too, eventually be challenged.

Good games create and support the cycle of expertise, with cycles of extended practice, tests of mastery of that practice, then a new challenge, and then new extended practice (Gee, 2004). While engineering plays a crucial part in everyday life, engineering education is seldom based on challenges, experiences and on leaving school as an expert. University curricula do provide a steady theoretical base for those students aiming to become industrial engineers, however the absence of practice-oriented, high-risk and high-responsibility tasks makes them vulnerable and unprepared in any tough industrial environment (Bajor et al., 2014).

When considering maturity in thinking and meta-cognitive activities on problem solving, several approaches have been suggested. Among them are Bloom's taxonomy (Bloom, 1956) , SOLO taxonomy (Biggs & Collins, 1982), Chi's experts versus novices (Chi, 1981) , and Piaget's assimilation versus accommodation (Piaget, 1953). Students enter tertiary education as novices, and the role of the university is to transform them into responsible and reliable engineering experts.

There are a number of characteristics that differentiate the experts from the novice problem solvers. The most familiar distinction is that the experts think about, consider, and examine the problem as a whole before beginning to work on a solution. They classify a problem according to its underlying principles, deciding to what class of problem it belongs. They engage in a planning stage before attempting a solution(Hassan et al., 2011).

The foundation of the developed environment is based on Bloom's taxonomy. Bloom's Taxonomy was created in 1956 under the leadership of educational psychologist Benjamin Bloom in order to promote higher forms of thinking in education, such as analyzing and evaluating concepts, processes, procedures, and principles, rather than just remembering facts (rote learning). It is most often used when designing educational, training, and learning processes. Bloom identified three domains of educational activities or learning (Bloom, et al. 1956):

- Cognitive: mental skills (knowledge)
- Affective: growth in feelings or emotional areas (attitude or self)
- Psychomotor: manual or physical skills (skills)

Traditional teaching styles mostly concentrate on the cognitive and to some extent, on the affective domain, while the psychomotor domain is often overlooked. For future engineers, it is necessary to develop psychomotor skills related to the discipline because the role of an engineer is to do either or both of development work of products and systems and to direct other people in the development, maintenance and manufacturing of products and systems (Ferris & Aziz, 2005). In situations where the engineer personally performs work related to developmental experimentation, prototyping or maintenance, it is necessary to have appropriately developed skills to be able recognize and handle components and equipment used. In cases where the engineer's role is to direct the work of others, it is crucial to have appreciation of the tasks and to have sufficient experience to understand the potential difficulties and dangers associated with the performance of the tasks. The goal of the developed game-based environment was to create a framework that embraces all three of Bloom's domains, and develops student skills on a wider spectrum than traditional education.

The framework is based on a model that represents a car factory, where series of cars (1-3-5-10) are being assembled. The environment consists of two main components: the plotting board (which symbolizes a factory) and the car – which is the main product of the factory. The game is led by a game master (usually a skilled expert of both engineering and psychology), who is responsible for the flow of the game and who provides feedback on student performance.

The goal of the game-based learning experience is to assemble series of non-official LEGO cars as accurately and as fast as possible. Players restructure and reengineer the production line, and allocate different tasks to different people, or different people to different tasks. Participants however do not compete against each other, all actions are executed to reach the goal of reducing the time request and improving the productivity and quality rate of the production process. Production is divided into rounds, when each participant performs a unique, pre-defined task in the assembly line according to a given order, instruction or later, the decision of the team.

The plotting board is divided into four workstations and engages four players at a time. Between the workstations four drawers are situated to provide the transportation of materials. The plotting board is equipped with an automatic measurement system, which registers time-stamped data of the production process. The data is later evaluated by forming KPIs and productivity indexes.

The game was designed to be a round-by-round activity – breaks between the rounds provide an opportunity to instant feedback and evaluation. Players receive both qualitative and quantitative feedback. Quantitative feedback is based on data recorded by the measurement system of the plotting board and is used to develop detailed statistical data. This provides objective, numerical feedback and points out bottlenecks, inefficiencies and development opportunities. Qualitative feedback is provided by game masters and by other players and it supports players to react on quantitative feedbacks by more deeply expressing what others do or do not like and what they believe could be improved.

The game provides a learning by doing experience on the most widely used logistics strategies, outlines the frame of a production line and systemic thinking. Players are supported to recognize critical factors in production processes and to improve capacity utilization. In-built bottlenecks and errors induce problem detection and improved quality check. Instant qualitative and quantitative feedback highlights the importance of performance measurement and evaluation.

Overall, the game provides real-life experiences in a classroom atmosphere, where mistakes are not considered as failures, but challenges, and where successful teamwork, negotiation and communication are the keys to succeed.

5. Assessment and evaluation – method and results

5.1 Method

A sample of 86 undergraduate engineering students of one Spanish and one Hungarian public universities participated in the study, including 52 males and 34 females. Fifty nine percent of the participants frequented the Bologna's 1st cycle studies (N=51), and forty one percent the 2nd cycle studies (N=35).

Tests were conducted in three phases: before, during and after the learning by doing experience (see timeline on Figure 1.). The research applies between-method triangulation as it contrasts several research methods such as questionnaires, observations and interviews, as well as technical measurements.

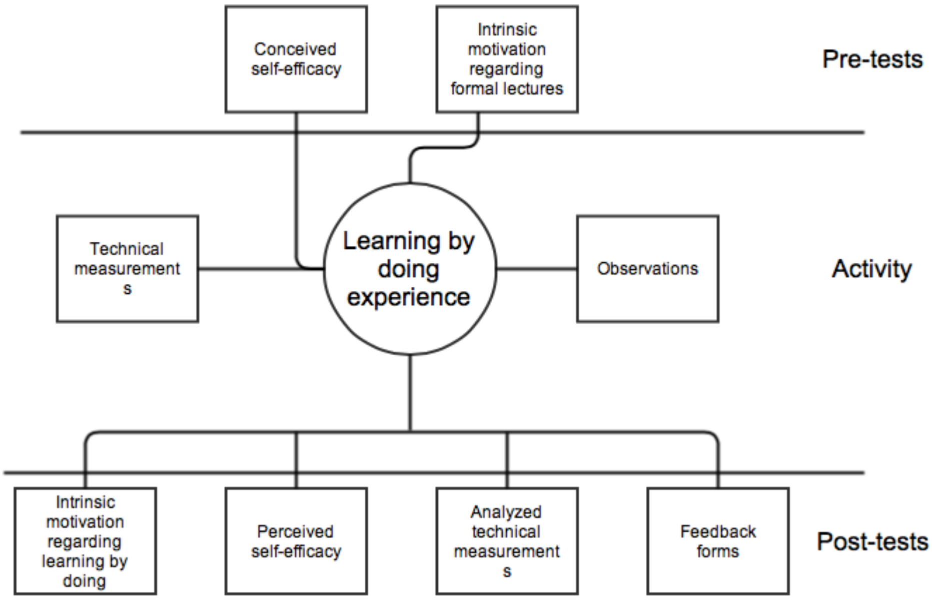

Figure 1: The assessment process

In the pre-activity and post-activity phases self-efficacy and intrinsic motivation and attitudes towards formal education are assessed.

Conceived self-efficacy is measured using Bandura's Guide for Constructing Self-Efficacy Scales (Bandura, 1997). Self-efficacy is concerned with people's beliefs in their capabilities to produce given attainments. Participants were instructed to estimate their ability with respect to several, work-related situations. The scale consists of eleven statements and participants have to respond to each one according to a 10-point scale, in a range from 1 (complete inefficiency) to 10 (full proficiency).

Intrinsic motivation is assessed using the Intrinsic Motivation Inventory (IMI). IMI is a multidimensional measurement device intended to assess participants subjective experience related to a target activity in laboratory experiments. It has been used in several experiments related to intrinsic motivation and self-regulation (e.g., Ryan, 1982; Deci & Ryan, 1985; Deci et al., 1995). The instrument assesses participants' interest/enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, perceived choice and relatedness while performing a given activity – thus yielding seven sub-scale scores. Before the active learning experience, students were asked to rate an average, professor-centered lecture, while after the lecture, to rate the active, student-centered experience in the IMI framework. Answers were provided on a 7-point Likert-scale, in a range from 1 (not at all) to 7 (absolutely).

During the activity, technical measurements and field observations are conducted. Technical measurements are made by the integrated microcontroller of the plotting board and by the game masters using a special smartphone app designed by our research group to measure assembling times. The controller logs active and inactive times, the movement and position of drawers, as well as the timestamp of sent and received kanban signs. Recorded data is transmitted to a computer and it is formed into performance indicators. Gained performance indicators are later collated with conceived and perceived self-efficacy results and with the observations recorded and evaluated by game masters.

The post-activity phase consists of the perceived self-efficacy questionnaire, the post-IMI questionnaire, the forming and evaluation of performance indicators and the collection of student feedback forms. The feedback form consists of four questions regarding the learning by doing experience. Feedback forms were assessed off-lecture (as part of a homework assignment).

5.2 Results

Self-efficacy questionnaires were distributed before and after the learning by doing experience. Participants rated their conceived and perceived self-efficacy on a 10-point scale regarding eleven, work-related statements (see results on Figure 2.). The statements focused on attention, following orders, making decisions and handling work related stress and other situations.

Results have shown that in 8 out of 11 questions, students rated their performance lower after the learning by doing experience then they did before (average scores: before - 94,2/110 points, after – 85,7/110 points). While technical measurements shown significant development in both assembling times and accuracy, student ratings relating to those particular questions were also lower in the post-activity period (question 1,2,4). These findings indicated further investigation, since one of the hypotheses of the research was that students are going to be more confident about their skills and rate themselves higher after the active learning experience. Deep interviews and group meetings with the participants later revealed that the reason for the results is that students underestimated the importance of basic skills in work related situations, while overestimated their own abilities in performing basic skills before they participated in the learning by doing lecture.

Students also indicated that the mentally and physically (psychomotorically) active and tense environment enabled them to observe their own performance according to the given guidelines (the conceived self-efficacy questionnaire), enhanced self-criticism, while the discovery of lacking and the opportunity of developing basic skills engaged them more in the learning process. These findings also tally with the fact that those questions receiving a higher rating in the post-activity phase were the ones focusing on recognizing own mistakes and paying attention on one's own work.

Besides self-efficacy questionnaires, observations and technical measurements, the toolkit of Intrinsic Motivation Inventory was used to assess student attitudes towards traditional and hands on lectures. Although all motivation is based on some reward variation, external, tangible reinforcement or internal fortifications (ie, self-satisfaction), the underpinnings of IMI emphasize autonomy and competence by means of choice, control, and an interpersonally supportive climate (Deci et al., 2008). When students are intrinsically motivated for learning, they engage in targeted behaviors because of the interest, enjoyment, and satisfaction derived from their engagement in the activity, rather than due to external rewards (Medalia & Saperstein, 2011).

Results (see on Figure 3.) have shown that students rated their feelings towards the active learning experience higher overall then professor-centered lectures. While the invested effort (3) and felt tension (5) were relatively the same, the interest/enjoyment (1), perceived competence (2), value/usefulness (4) and perceived choice (6) factors were significantly higher at the case of the hands on activity than it is for traditional, teacher centered lectures. Besides, students also indicated that they could relate to and rely on each other (7), which is something they miss from traditional lectures overall.

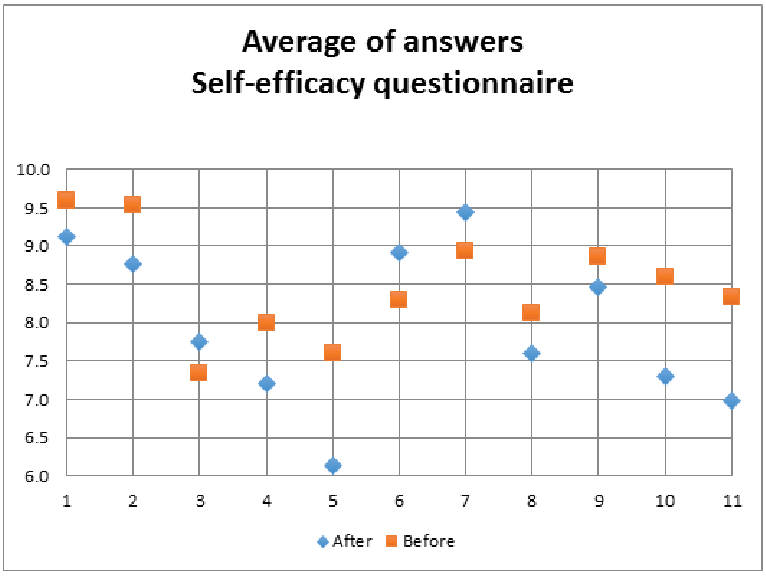

Figure 2: Average of answers – Self-efficacy questionnaire

While a relatively high proportion of students were unsure of the goals and outcomes of formal lectures, the hands on activity enabled students to understand the perceived learning outcomes and pedagogical goals, as well as the usefulness of the endured experience in regards of real life problems and work related situations.

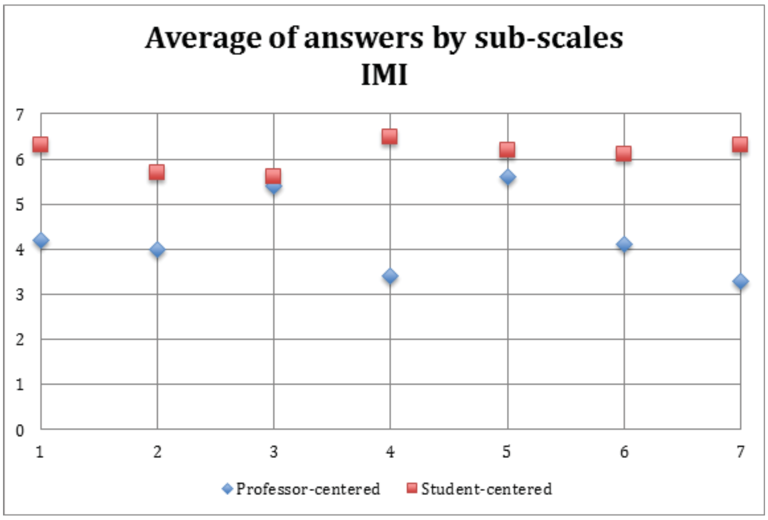

Figure 3: Average of answers by sub-scales, IMI

Feedback forms were distributed to all participating students (N= 86) as part of a homework assignment. Participants were asked to reply to four open questions about the active learning environment (eg. "Would you recommend the program to your fellow students?" or "Did you learning something about yourself or about your future profession during the learning by doing lecture?"). Response rate was 100%, and the lecture has received positive feedback - 95% of students enjoyed the activity and would recommend his/her classmates to participate in it. Many of the participants also indicated that they have developed critical and important personal skills (such as negotiation skills, decision making, teamwork, handling stress and tension), while they have also learned key competences related to work (such as the importance of measurements, performance measurement and indicators, organization and planning).

6. Conclusions

As students learn in many ways, teaching methods also vary in higher education. Some instructors lecture, others demonstrate or discuss; some focus on principles and others on applications; some emphasize memory and others understanding. How much a given student learns in a class is governed in part by that student's native ability and prior preparation but also by the compatibility of his or her learning style and the instructor's teaching style. (Felder & Silverman, 1988) Mismatches between common learning styles of engineering students and traditional teaching styles of engineering professors result in bored students and inattentive class, poor tests, and in some cases in changing to other curricula or in dropping out of school. Confronted by low test grades, inactive classes, poor attendance and dropouts, professors may become overly critical of their students or begin to wonder if they are in the right profession. And most importantly, society loses potentially excellent engineers.

While many higher educational institutions have already recognized the importance of introducing alternative teaching techniques into their curriculum, most of these approaches are developed and applied independent of each other. Besides mostly applied locally, these alternative approaches aiming to develop the core skills of engineering students are usually separated from hard skill development, and overall, from hard science. Moreover, the absence of deliberate, harmonized and comprehensive assessment and evaluation methodologies, and the lack of communication between the parties makes it very difficult to compare already existing approaches. While there are several up-to-date, upcoming educational approaches aiming to address the challenges of contemporary engineering education, complex, unified and effective methodologies are still missing from the toolkit of higher education.

The purpose of this paper is to assess and evaluate a game-based learning experience, but also to introduce an environment that can be applied to enhance both hard and soft skill development at any stage of tertiary education. Preliminary results has shown that students not only enjoy the game-based experience more than traditional lectures, but the perceived connection between real-life and in-game problems generates higher level of motivation and engagement, while also enables students to develop their negotiation, decision making and systemic thinking skills, and prepares them for the challenges of the labor market that awaits outside the university. The future direction of this research is to develop and provide a complex, statistics-based evaluation methodology that may enable researchers to study and evaluate active learning environments in a more unified and standardized way – whilst enabling to create a platform where certain methodologies can be scientifically rated and evaluated before further application.

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From Hiscore to High Marks: Empirical Study of Teaching Programming Through Gamification

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Abstract: Unlike conventional taught learning, video games are very successful at keeping players constantly motivated and engaged on a set of tasks for many hours without apparent loss of focus. Additionally, when playing, gamers solve complex problems without experiencing the fatigue or frustration, which would normally accompany a comparable learning task. Any methods able to deliver deep learner engagement are naturally of interest to the academic community, thus resulting in an increasing interest in adopting gamification – the integration of gaming elements, mechanics, and frameworks into non-game situations and scenarios – as a means to drive student engagement and improve information retention. However, its application to education has been a challenging task, as attempts have generally been restricted to a one-dimensional approach, such as transposing a trivial reward system onto existing teaching material. The empirical evidence presented in this paper suggests that a gamified, multi-dimensional, problem-based learning approach may yield improved outcomes even when applied to a very complex and traditionally dry task like the teaching of computer programming. This quasi-experimental study employed a real time sequence of scored quizzes, instructor feedback, and live coding to deliver a fully interactive learning experience. By using a combination of the classroom version of the TV game show "Who Wants To Be A Millionaire?", the "Kahoot!" Classroom Response System (CRS), and Codecademy's online interactive platform on a Python programming course, students were allowed to experience multiple interlocking methods similar to what would be found in a top quality game experience. Empirical data on learning outcomes from the gamified group were compared with a control group that followed a traditional learning path, which had been used during previous cohorts. Whilst this was a relatively small study, the results were quite interesting in a number of key metrics, including attendance, downloading of course material, and final grades.

Keywords: gamification, game-based learning, learning and teaching, technology enhanced learning, virtual learning environment, classroom response system

1. Introduction

According to research on the dynamics of attention spans during lectures, the typical learner's attention increases during the first ten minutes of lecture and diminishes after that point (Hartley and Davies, 1978). One way to address this issue and recapture the attention of learners is by changing the environment during a lecture, e.g., via a short break (McKeachie, 1999). This is almost the opposite of the dynamic experienced by video gamers. The latter are kept at high levels of attention, which in some cases can last for many hours (Green and Bavelier, 2006). They also have a distinct characteristic where they strive to be on the verge of what Jane McGonical (2010) mentions as an "epic win". Gamers also share common factors such as urgent optimism, social fabric, blissful productivity, and epic meaning, which in turn make them super empowered hopeful individuals (Huang and Soman, 2013).

Gamification for learning would add game mechanics, dynamics, and frameworks to non-game processes in an effort to combine intrinsic with extrinsic motivation so as to raise student engagement and motivation (Deterding et al., 2011). Intrinsic motivation (e.g., altruism, competition, cooperation, sense of belonging, love or aggression) is driven by an interest or enjoyment in the task itself and inspires people to initiate an activity for its own sake; it exists within the individual instead of relying on external pressures or a desire for reward (Ryan and Deci, 2000). Students who are intrinsically motivated are more likely to engage in a task willingly, as well as work to improve their skills, which will increase their capabilities (Wigfield et al., 2004).

However, despite the fact that gamification of education is gaining support among an increasing number of academics who recognise that effectively designed games can stimulate large gains in productivity and creativity among learners (NMC Horizon Report, 2014), opponents argue that what is lacking is concrete empirical data to support of refute these theoretical claims (Annetta et al., 2009; Barata et al., 2013). Some of the negative experiences include disappearance of collaboration among students and overstimulation of competitiveness. The balance between learning, social collaboration, creativity, and competitiveness which is apparent in mainstream commercial games seems to be hard to achieve in tools specifically designed for education (Zaha et al., 2014). As a result, gamification is often reduced into a behaviour model leveraging human need for positive reward system and instant gratification, which is applied to a traditional teacher-centred classroom. The present paper aspires to make a contribution to the empirical evidence in the gamification field by designing, implementing and evaluating a gamified learning experience in a higher education setting in an effort to bridge the gap between theory and practice.

2. Related works

The new millennium saw the introduction of the terms "ludic engagement", "ludic design", and "ludic activities" to describe "activities motivated by curiosity, exploration, and reflection", as well as the emergence of a new field called "'funology' – the science of enjoyable technology" (Blythe et al., 2004) which was inspired by game design and studied "hedonic attributes" (Hassenzahl, 2003) or "motivational affordances" (Zhang, 2008) of "pleasurable products" (Jordan, 2002).

The use of video games for educational purposes was also emphasized by the works of Prensky (2001) and Gee (2003). Although these studies were related to game-based learning rather than gamification, their findings form the core of gamification in education: they described the influence of game play on cognitive development, identified 36 learning principles found in video games, and recognised potential advantages of video games in learning such as the value of immediate feedback, self-regulated learning, information on demand, team collaboration, and motivating cycles of expertise (Borys and Laskowski, 2013). However, due to the wide range of course types, learning preferences, student backgrounds, and socio-economical environments, more systematic studies of the influence of different gamification techniques are required in order to assess their efficiency (Barata et al., 2013).

3. Methodology

3.1 Study design and sample

Teaching and assessment of computer programming is considered to be difficult and frequently ineffective, which often results in undesirable outcomes such as disengagement, cheating, learned helplessness, and dropping out (Robins et al., 2003). Based on the concepts of the increasingly popular gamification, game-based learning and serious games movements, the present paper evaluates how gamification affected students of a 12-week university course named Fundamentals of Software Development (FSD) via the use of the Kahoot! CRS, a classroom version of the TV game show "Who Wants To Be A Millionaire?" (WWTBAM), and Codecademy's online interactive platform.

To reach this objective, faculty staff composed of three lecturers conducted a quasi-experimental study over two consecutive academic years at the University of West London. The sample included a control class (CC) of N_{con} = 54 students (43 males, 11 females) who attended the FSD course in the first year of the study, and an experimental class (EC) of N_{exp} = 52 students (44 males, 8 females) who attended FSD in the second year.

During the first year, FSD followed a non-gamified approach that was similar to the ones used in previous years. The syllabus included 12 regular one-hour lectures, 12 two-hour laboratory classes, and 12 one-hour seminars. The theoretical lectures covered Python programming concepts ranging from loops, functions, and object-oriented programming, to GUI applications and videogame development. In laboratory classes students were presented with a series of programming tasks that they had to complete individually during the session, with the tutors offering occasional help. Finally, seminars were used for revision purposes and were delivered via a combination of Q+A and typical lectures. All course materials were uploaded to the institutional Virtual Learning Environment (Blackboard) on a weekly basis. The course evaluation consisted of 6 theoretical quizzes (30% of total grade), and 2 mandatory assessments: a final exam (35%) and a programming project (35%).

An analysis of the student performance data at the end of the first year showed low attendance rates, numerous late arrivals to classes, and lack of interest in the reference material (low number of downloads that increased only before the exams period). In order to address these issues and to make FSD more fun and engaging, teaching methods changed in the second year to incorporate gamification. Literature indicates that educational gameplay fosters engagement in critical thinking, creative problem solving, and teamwork (NMC Horizon Report, 2014). When students are actively engaged in the content that they are learning, there is increased motivation, transfer of new information and retention (Premkumar and Coupal, 2008). Additionally, the attention span of students diminishes after the first 15-20 minutes into a lecture (Middendorf & and Kalish, 1996). Based on these facts, while the course evaluation remained the same, the delivery of the course was gamified as follows.

3.2 Gamification of the course

3.2.1 Formative assessment using Kahoot!

The initial one-hour theoretical lectures were replaced by three 20-minute cycles comprised of a micro-lecture, a formative assessment in the form of a game of Kahoot! and a brief discussion. Kahoot! is a game-based CRS that uses colourful graphics and audio to temporarily transform a classroom into a game show, with the lecturer acting as the show host and the students being the competitors. Once everyone had joined the game, the lecturer's computer, which was connected to a large screen, displayed a set of 5 multiple-choice (MC) questions related to the preceding micro-lecture. The students then input their answers on their digital devices and earned points based on how fast they answered correctly (Figure 1). Between each question Kahoot! showed a distribution chart of the students' answers, thus allowing the lecturer to receive immediate feedback on whether concepts had been understood by the whole class or required further elaboration; consequently, a scoreboard displayed the nicknames and scores of the top five students, and at the end of the game a winner was announced and received some candy as a reward.

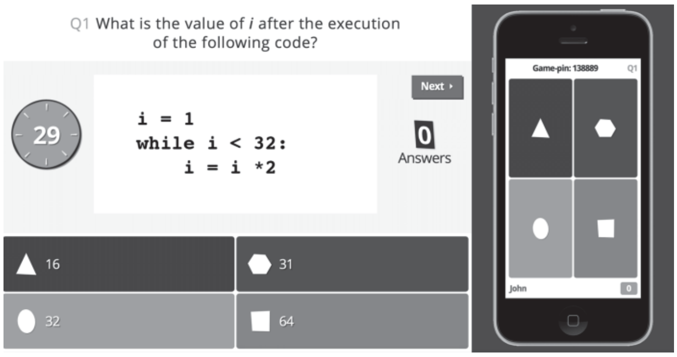

Figure 1: "Kahoot!" in-game screenshot

Following the game's completion, the lecturer discussed briefly all answers to each question and downloaded a spreadsheet of the results in order to get an overview of the individual student and overall class performance. Each student's score was updated every week and was entered to a leaderboard webpage, which was publically accessible through Blackboard and displayed enrolled students in descending order according to their total points. This visual display of progress and ranking provided students with direct feedback on their performance against both their own goals and the performance of their peers, while also serving as instant gratification.

3.2.2 Collaborative problem solving with "Who Wants To Be A Millionaire?"

The one-hour revision seminar was also changed; the combination of Q+A and lectures that took place during the first year was replaced by an open-source implementation of WWTBAM, a television quiz show that offers a top prize of $1 million for answering correctly successive MC questions of increasing difficulty (Figure 2). The version of the game used in the classroom featured 540 Python-related MC questions (3 sets of 15 questions per week), which were created by the lecturers through a straightforward process that required the editing of a simple text file. For logistic purposes, the class was randomly divided into four groups of 13 students (11 male, 2 female) who attended a separate seminar every week for a total of 12 weeks. During the first seminar, each group was randomly split into three teams of 4-5 contestants that remained the same for the duration of the course, and then the gaming activity started as outlined below.

Each team was seated in front of the class facing the screen with their backs to the audience so that they could not receive any unsolicited assistance. Students were then asked 15 increasingly difficult questions on Python programming which covered a different topic every week. Since some of these questions were also scheduled to appear in the 6 theoretical quizzes, in fairness to the team of student contestants all other students in the class were instructed to put away their note-taking materials for the duration of the game. This also enhanced the perception that the class was taking a break. Although there was no official time limit to answer a question, each game's duration was limited to 20 minutes in order to give all teams the opportunity to play once during the seminar. Questions were multiple-choice: 4 possible answers were given and the team had to collaborate, reach a consensus, and give a single response. Additionally, at the beginning of each game contestants were presented with an aid of three lifelines:

- Poll The Class: All students provided their answers for a particular question by raising their hands and the percentage of each specific option as chosen by the class was displayed to the contestants.
- 50/50: The game eliminated two incorrect answers, thus leaving contestants with one incorrect and the correct answer to choose from.
- Ask A Friend: Contestants had 30 seconds to read the question and answer choices to a non-team classmate, who in turn had the remaining time to offer input.

After viewing a question, the team could respond in one of three ways:

- Refuse to answer the question, quit the game, and retain all points earned up to that point.
- Answer the question and, if their answer was correct, earn points and continue to play, or lose all points earned to that point and end the game if incorrect. However, the £5,000 and £100,000 prizes were guaranteed: if a team got a question wrong above these levels, then the prize dropped to the previous guaranteed prize.
- Use a lifeline (Ask A Friend, Poll The Class, or 50/50).

The game ended when the contestants answered a question incorrectly, decided not to answer a question, or answered all questions correctly. All answers to each question were conscientiously reviewed for the entire class as the game proceeded. This discussion of the relative merits of the various provided answers was an integral part of the learning process that took place during the execution of the game.

At the end of every seminar, newly earned points were added to the points carried from previous weeks. The whole scoring process was done manually, with points being collected by faculty and then added to a leaderboard webpage on Blackboard, which showed the team rankings for every group and provided an entry point to the gamified experience. After all 12 seminars were completed, the leading team won the title of "Pythonista of the year" and received chocolate bars as an award. Finally, in order to promote self-assessment and allow students who missed the seminar sessions to experience this alternative form of learning, the game and its latest set of questions became available for downloading at the end of every week.

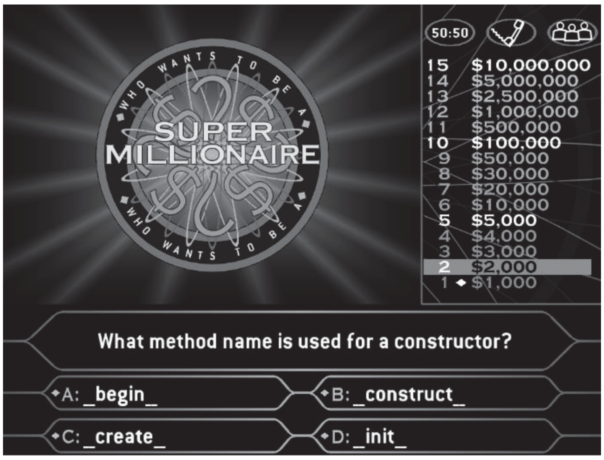

Figure 2: "Who Wants To Be A Millionaire?" in-game screenshot

3.2.3 Practicing programming skills with Codecademy

To make the laboratory classes more interactive and engaging, Codecademy was selected as the delivery platform for the programming exercises. Founded in 2011, Codecademy is one of the most popular online education providers with over 24 million users to date (Richard Ruth, 2015). It offers free coding courses tailored for the new computing syllabus in the UK in a number of programming languages, including Python. Additionally, it serves as a competitive virtual classroom that allows students to track their peers' achievements and work to match or outdo them.

In the first laboratory session, lecturers created an "FSD Class" containing 36 lessons of Codecademy's Python track that were mapped to the syllabus of FSD. Students were then asked to sign up and create a pupil account, which was used to enrol them to the FSD class. From that point lab sessions proceeded as follows: every weekly session began with a five-minute introduction to the exercises for the day, and then students were required to complete a certain number of Codecademy lessons based on the topics that had been covered until then. Each lesson was broken down into bite-sized chunks and comprised of practical exercises accompanied by notes that explained the programming techniques and terms used. After reading the exercise instructions, students would type in their Python code to the code window, submit their code for execution, and see its output in a separate window. If the code were erroneous, they would receive an error message and would have to try again. Once they managed to solve the exercise, they would earn points and proceed to the next lesson. Students who were not able to finish on time could continue the lessons independently and at their own pace at home, while students who finished early and wished to further their programming skills were provided with additional exercises.

The Codecademy platform provided students with direct feedback on their progression via graphical representations such as completion indicators for each lesson and for the overall course, badges and points for various achievements etc. This served as instant gratification and offered an added dimension to learning, as students could track their peers' scores and try to surpass them. In an effort to motivate students to complete the exercises as quickly as possible, the lecturers set a number of different challenges, e.g., highest score achieved in 1 and in 4 weeks, fastest student to reach 50, 100, and 200 points etc. However, no actual physical rewards were given to the winners. The rationale for this decision was to allow faculty staff to evaluate whether the aim of winning a challenge was in itself enough as intrinsic motivation for students to complete their tasks. Each challenge had its own leaderboard, which was made accessible to the students through Blackboard.

4. Results

To ensure that the gamified approach encouraged students' active participation in the educational process, formative and summative assessments of student engagement were performed using the following methods (Jennings and Angelo, 2006):

- Observation of student behaviour.
- Online survey exploring the effects of gamification in the classroom.
- Students' self-report of activity through focus groups and semi-structured interviews.
- Collection of administrative data such as student attendance, late arrivals to class, number of reference material downloads, lab exercises' completion rate, and academic performance.

4.1 Observation of student behaviour

In regards to classroom observation of student behaviour, the majority of the EC students demonstrated the following characteristics during all seminar, lectures, and laboratory sessions, which are considered immediate indicators of engagement (Franklin, 2005; Mandernach et al., 2011):

- Actively listened, focused attention and made eye contact;
- Responded to the lecturer's prompts;
- Actively participated in the WWTBAM and Kahoot! games, and in the Codecademy challenges;
- Questioned, explored, brainstormed or discussed the WWTBAM and Kahoot! question topics with their peers and lecturers;
- Utilised decision-making or problem solving skills in questioning and responding;
- Demonstrated body language that was open and relaxed with appropriate smiles or laughter.

4.2 Online survey exploring the effects of gamification in the classroom

To gather quantitative feedback about the effectiveness of the gamified experience, all EC students (N_{exp} = 52) completed a 15-question online survey at the end of the semester. Every question had 5 possible answers measured on a Likert scale of 1 (Strongly Disagree) to 5 (Strongly Agree).

#	Question	Disagree		... - ...		Agree	Aver.	Var.	Dev.	Med.
		1	2	3	4	5				
1	The games made the learning environment a fun and engaging one.	0.0%	0.0%	9.6%	13.5%	76.9%	4.7	0.4	0.6	5
2	The games motivated me to attend classes.	0.0%	0.0%	48.1%	25.0%	26.9%	3.8	0.7	0.8	4
3	The games motivated me to arrive to class on time.	0.0%	9.6%	36.5%	26.9%	26.9%	3.7	1.0	1.0	4
4	I was more motivated to study the course material every week in order to do well in the leaderboard for the games.	0.0%	0.0%	34.6%	50.0%	15.4%	3.8	0.5	0.7	4
5	I communicated with other players while playing.	0.0%	0.0%	9.6%	15.4%	75.0%	4.7	0.4	0.7	5
6	The total duration of the games was satisfactory.	0.0%	0.0%	11.5%	36.5%	51.9%	4.4	0.5	0.7	5
7	I was comfortable with adding the Top-5 leaderboard to the module's Blackboard page.	0.0%	0.0%	34.6%	25.0%	40.4%	4.1	0.8	0.9	4
8	The discussions about the correct and incorrect answers after every question (i.e., why wrong answers were wrong, and right answers were right) were satisfying.	0.0%	0.0%	11.5%	34.6%	53.8%	4.4	0.5	0.7	5
9	I believe that the games have improved my understanding of the covered topics.	0.0%	0.0%	23.1%	48.1%	28.8%	4.1	0.5	0.7	4
10	Performing well in the games increased my self-confidence.	0.0%	0.0%	9.6%	50.0%	40.4%	4.3	0.4	0.6	4
11	I would have prepared and engaged better if the game results were translated to actual marks for the module assessment.	0.0%	23.1%	36.5%	25.0%	15.4%	3.3	1.0	1.0	3
12	I believe that the games have improved my analytical and problem-solving skills in terms of developing solutions for Python challenges.	0.0%	9.6%	34.6%	26.9%	28.8%	3.8	1.0	1.0	4
13	I wish Kahoot! and "Who Wants To Be A Millionaire" were used in other modules.	0.0%	0.0%	32.7%	26.9%	40.4%	4.1	0.7	0.9	4
14	I believe that gaming is a valuable use of instructional time	0.0%	0.0%	30.8%	32.7%	36.5%	4.1	0.7	0.8	4
15	I found the use of the leaderboard intimidating.	53.8%	25.0%	21.2%	0.0%	0.0%	1.7	0.7	0.8	1

Figure 3: Online survey results

According to the weighted Likert scale average shown in Figure 3, students mostly agree that the classroom games made learning fun and would like to see them introduced to other modules as well. Students were also generally motivated to attend classes and arrive on time, a finding that was also supported by the administrative data collected at the end of the course. Most students communicated with their peers while playing and believed that performing well in the games increased their self-confidence. Additionally, they were not intimidated by the use of leaderboards and some of them even studied the course material on a weekly basis in order to appear high in the leaderboard rankings. The discussions about the correct and incorrect answers after every Kahoot! and WWTBAM question were deemed satisfying and improved the students' understanding of the cover topics. Surprisingly enough, there were mixed opinions about getting some tangible rewards, such as translation of game points into actual marks for module assessments. Finally, most students considered gaming a valuable use of instructional time as they felt it helped them improve their analytical and problem-solving skills.

4.3 Semi-structured interviews for in-depth student feedback

To get extra insight into the survey results, qualitative research was conducted in the form of focus groups and semi-structured interviews with a small number of students, featuring questions on collaborative learning, cognitive development, and personal skills development. As demonstrated by the following sample of responses, the overall reaction by interviewees was extremely positive:

- "I know that I have learned from watching other people play WWTBAM, as well as through playing myself."
- "It makes you feel like you've learned something when you complete a lesson in Codecademy."
- "Seeing my name at the top of the leaderboard made me feel smart and proud."
- "Although I am rather shy and quiet as a person, playing WWTBAM boosted my confidence and made it easier for me to collaborate with my classmates."
- "I enjoy Kahoot! because it's always fun to beat your classmates."
- "Lectures don't feel boring anymore."

4.4 Analysis of the administrative data

As a means of gauging student persistence, interest, and effort in the gamified classes, there was a comparison of the attendance and the late arrivals (students arriving to class with at least a 10-minute delay) among the control and the experimental classes (Figure 4). Average class attendance for CC was 65% (≈35 students), while EC had an average class attendance of 78% (≈42 students). Additionally, an average of 4 to 5 CC students and 1 to 2 EC students arrived to class late every week, respectively. Both findings suggest that gamification motivated EC students to be more punctual and attend classes more often than their CC peers.

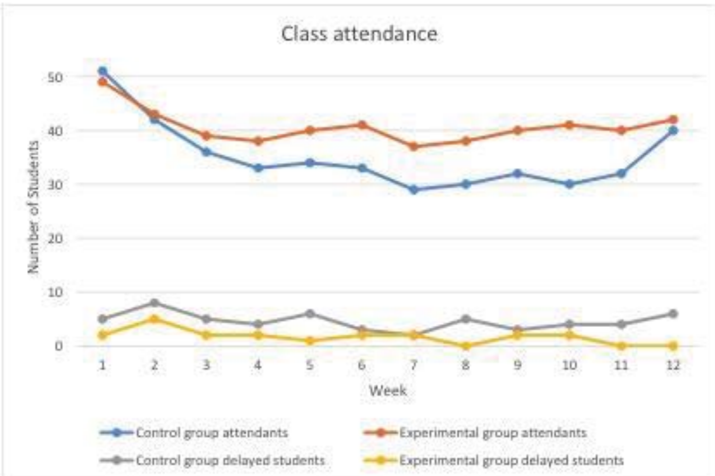

Figure 4: Weekly class attendance

In regards to the number of the reference material's weekly downloads, CC students demonstrated a lack of interest with an average of 1.2 weekly file downloads per student, which spiked only during the week preceding the final exams; in comparison, every EC student downloaded 1.7 files every week. When combined with the survey's results, this could suggest that EC students were motivated to download and study the course material every week in order to perform well in the classroom games.

While the CC completion rate of the practical exercises remained roughly around the 50% mark for every laboratory class, EC students showed a small but steady weekly increase in their completion rate, which might indicate that the weekly challenges motivated them to try harder so as to complete their exercises and improve their programming skills. Finally, EC had the best overall academic performance with an average final grade of 61% compared to CG's 53%. However, due to the relatively low number of participants, additional studies are needed to identify possible correlations between gamification and academic performance.

5. Conclusion and future work

The aforementioned findings suggest that using a multi-dimensional gamified learning approach has successfully achieved the pedagogical goals outlined in the introduction. Based on the concepts of the increasingly popular gamification, game-based learning and serious games movements, it gives teachers and students the opportunity to experience first-hand how game mechanics can be used to make learning fun and addictive. Coupled with effective pedagogy, games can offer more effective and less intrusive measurement of learning than traditional assessments.

Both Kahoot! and WWTBAM serve as an opportunity for instant application of knowledge and allow common programming language misconceptions to be revealed and explored. They also use similar game mechanisms to make students feel good about their accomplishments and overcome their personal records. Kahoot! provides students with the opportunity for self-assessment through a fun and engaging atmosphere, which allows them to master new programming concepts relatively quickly. As for WWTBAM, it requires students to compare and discuss their answers with their teammates in order to come to a consensus regarding the answer, thus honing important employability skills such as collaboration, problem solving, critical thinking, and communication.

This mix of individual and group competition in the classroom catered to the needs of diverse students, some of which preferred to initially develop their coding skills alone while others performed better in groups. As the semester progressed though, it was noticed that the students' engagement decreased slowly in the Kahoot! sessions; on the other hand, the engagement for WWTBAM remained unchanged. This could be attributed to the fact that students competing at individual level in Kahoot! began to lose interest once they trailed behind in the leaderboard. Another concern from the teaching staff's point of view was the limited length of the multiple-choice questions and answers in both games, which made their authoring quite challenging.

The use of Codecademy's points and badges as the sole motivator for completing the practical exercises also provided some interesting insights. Although students were intrinsically motivated to complete their exercises and generally performed better than their CC peers, they expressed some concerns about the lesson contents, saying that some lessons were not always a good fit to the FSD syllabus, lacked clear instructions, and had ambiguous explanations and vague error messages. As a result, students who struggled on a particular aspect of programming due to the poor quality of that particular set of lessons tended to associate that aspect with being difficult to grasp and master, when it was not necessarily so. A possible yet rather demanding solution to this problem would be to provide students with a more personalised experience by developing lessons specifically for the FSD syllabus. Additionally, data analytics could be used to identify which programming concepts are more challenging for students, so as to give the latter opportunities for more practice.

Whilst the results are encouraging, the authors acknowledge that the limited nature of this study does not preclude the possibility that the improvements in student engagement are simply the result the short-term "novelty" factors generally associated with the introduction of new technology / techniques. Further study is needed to assess whether the increased student engagement suggested by these methods is sustainable and applicable to other subjects.

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Immersive vs Desktop Virtual Reality in Game Based Learning

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Abstract: Virtual environments are recognized as more effective than other digital approaches for the acquisition of several abilities. This is because the brain recognizes the virtual world as real and this facilitates the transfer of the newly acquired skills to the real world. In this paper, we present a game that has been designed and developed with the aim of teaching spatial orientation abilities to teenagers with mild intellectual impairments. In particular, the game focuses on the training of two basic skills: perspective taking and mental rotation. Perspective taking refers to the ability of imagining how the world looks like from another person's point of view, while mental rotation is the ability to mentally represent and manipulate physical objects in one's mind. The game, which takes place in a virtual environment, shows the player a scene with some objects on the table. The player has to choose among four provided alternatives, the one that shows how the scene would look like from a different side of the table. The game was first developed to be used with either a desktop pc monitor or an interactive touch table. In this case, a virtual world is represented, but the player is not completely immersed in it, he just looks at the scene from outside. A second version of the same game has then been developed using a Head Mounted Display (HMD), which makes the player feel immersed in the virtual environment, where he can freely move around just as if it was real. In this paper, we discuss both advantages and disadvantages of the immersive Virtual Reality (VR) compared to the desktop VR. In fact, on the one hand, having the possibility to "dive" into the virtual world allows the player to: Better build a mental model of the scene and the involved objects by freely moving around the table and examining the objects from all the possible perspectives; Manage by himself the amount of help needed: it is always possible, at any time of the game, to move to the other side of the table and see what the scene looks like. Increase his involvement in the game by exploring the virtual world as he pleases. Have a better learning transfer thanks to the similarities between the virtual and the real worlds. On the other hand, using a HMD can be tiring and cause sickness to some players. Furthermore, the presence of a complete environment in which to move and explore, can draw the attention away from the main task of the game and therefore influence learning negatively. Experiments are planned to verify the foreseen advantages and disadvantages involving young adults with mild intellective disabilities.

Keywords: innovative games-based learning, virtual worlds, perspective taking, mental rotation

1. Introduction

1.1 What is virtual reality

Virtual Reality (VR) is defined as "an artificial environment which is experienced through sensory stimuli (as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment." (Merriam-Webster, 2015).

In VR, a concept that is frequently mentioned is "immersion". Jennett et al (2008) define immersion in games as the involvement in the play, which causes lack of awareness of time and of the real world, as well as a sense of "being" in the task environment. Immersion is not necessarily linked to the presence in space, but rather refers to an intellectual / emotional deep involvement into an activity.

When "immersion" is applied to VR, it usually refers to "spatial immersion". Spatial immersion into VR is the perception of being physically present in a non-physical world. The perception is created by surrounding the player with images, sounds or other stimuli that provide a very absorbing environment. Spatial immersion occurs when a player feels the simulated world is perceptually convincing, it looks "authentic" and "real" and the player feels that he or she actually is "there".

Even if immersion seems to be a crucial element for VR, as Robertson et al (1993) say, VR can also be non-immersive when it "places the user in a 3D environment that can be directly manipulated, but it does so with a conventional graphics workstation using a monitor, a keyboard, and a mouse". We will refer to this as a desktop VR.

Two main types of immersive VR can be identified:

- Cave Automatic Virtual Environments (CAVE): the user is in a room where all the walls and the floor are projection screens (or flat displays). The user can wear 3D glasses, he feels floating in the projected world where he can move around freely.
- VR glasses or other sorts of Head Mounted Displays (HMD), often used with headphones that can easily produce the visceral feeling of actually being in the simulated world.

Virtual environments are supposed to be more effective than other digital approaches with respect to the acquisition of several abilities. This is because the brain recognizes the virtual world as real and this facilitates the transfer of the learned skills to the real world (Rose et al. 2000), that is the ability to apply acquired knowledge or skills in different situations or environments. Furthermore, in an immersive virtual environment, the player can actually perform the movements that are characteristic to the skill he is practicing, favouring a kinaesthetic learning style.

From a literature survey (Freina and Ott, 2015), VR has been largely used for learning and training, especially in those cases in which the real world cannot be accessed. Such are, for example, the cases in which learning in the real world can be dangerous (e.g. crossing a street with heavy traffic) or impossible (e.g. floating in the solar system watching the planets move around the sun).

Nevertheless, VR can offer several advantages also in different situations: a large number of different scenarios in which the specific ability can be trained, the possibility to train several people at the same time with less tutoring effort, a better engagement of the students in the gaming activities, etc.

1.2 Promoting autonomy for people with mild intellectual disabilities

According to the Disabled World website (Disabled World, 2015), the “intellectual disabilities”, which include several different types of impairment, affect in between one and three percent of the world population. Fortunately, more than 90% of this population is able to reach some level of autonomous life and become socially engaged and active: they live on their own, have a job, attend courses, do some form of sport, etc.

In order to achieve these objectives, the ability to move around town autonomously and safely is fundamental. Nevertheless, acquiring this ability is not easy: spatial orientation can be a big issue, the acquisition of new skills can be a long and tiring process and transferring them to the real world situation is not straightforward. People with intellectual disabilities tend to learn more slowly and need a lot of field practice; the basic abilities for moving around in urban contexts are traditionally reached after a long training under the constant guidance of specialized tutors. The use of VR, in this case, would allow each user to have as much practice as needed and it could facilitate learning transfer.

Within this frame, the Smart Angel project (Smart Angel, 2014) co-financed by the Italian Liguria Region is oriented at supporting the social inclusion of people with intellectual disabilities, in particular by supporting their mobility in town and autonomous home living. Besides giving them a mobile cloud based system to help them face unplanned situations in their daily movements and a specific support for time management, a set of Serious Games has been developed to promote the acquisition of some basic abilities.

1.3 The addressed skill: Spatial intelligence

A certain level of spatial intelligence is needed in order to allow people to move around town avoiding getting lost. This basic level of spatial intelligence allows people to recognize a monument or a place in town also when seen from a different point of view and understand a sequence of directions by transposing the concepts of left and right to the new position.

Furthermore, spatial intelligence has been demonstrated to be an important complement to verbal thinking, it helps reasoning and shows correlation with success in STEM disciplines. Therefore, supporting the development of a good level of spatial intelligence is useful for all students.

Newcombe and Frick (2010) recognize two important skills involved in spatial intelligence: mental rotation and perspective taking.

- *Mental Rotation* is the capability to rotate an object in one's mind. Usually, children of 4-5 years are able to perform mental rotation, but the skill continuously strengthen through early childhood.
- *Perspective taking* is the ability to imagine ourselves as the observer and predicting what will be seen after an actual physical movement. In other words, the ability to identify the position and the orientation of other people in the space and understand that their perspective can be different from our own. This skill is under development during the early elementary years.

In intellectually impaired people, both these skills may develop later in age. Actually, while some people can easily reach good performances, others seem to have spatial impairments and lack the ability to perform specific tasks. The two abilities appear to rely on different cognitive operations even though they share common processes.

Surtees et al (2013) identify two levels of perspective taking: the first level that develops earlier in age is the ability to understand if a specific object can be seen or is hidden from another person's point of view. The second level, which appears to develop a little later, regards how someone else sees the world, therefore how a specific object, or an entire scene, would look like from a different position.

While some perspective taking tasks are visually based, therefore imply visual perspective taking abilities, others are more grounded into space. Spatial perspective taking is mentally occupying another's position in space and being able to understand the relative position of objects in space.

Surtees at al report their experiment in which the participants have to say if an object is placed in front / behind or left / right of another person. While performing the task, the body position of the participants is rotated, while the head is kept straight. Results show that rotation of the body influences response times only in identifying the left / right position, but not the in front / behind task. This suggests that an embodied representation of the scene and the person's movement are used. According to these results, it appears that embodied perspective taking processes are needed in some tasks; they are robust processes, effective in generating visual perspectives of other people. They are relatively costly and solve problems that are beyond the abilities of very young children.

2. The game idea

In this paper, we present a game that has been designed and developed with the aim of promoting the development of spatial orientation abilities in teenagers with mild intellectual impairments.

The game focuses on the training of two basic spatial skills: perspective taking and mental rotation. In particular, the chosen approach is based on the development of the embodied ability to mentally self-rotate oneself in order to be able to imagine how a scene would be seen by another observer. The target population we are referring to has already developed the skill to be able to understand if a given object can be seen by another person and if it stands in front or behind him. All the tasks within the game ask the player to imagine himself in a given position and tell what he would see.

The game, which takes place in a virtual home environment, shows the player a scene with some objects on a table. The player has then to choose, among four provided images, the one that represents how the scene would look like from another side of the table. The game is designed to be used by the target population with the constant presence of a tutor; nevertheless, it is possible to use it independently.

Two different versions of the game have been developed, both using Unity 3D. The first version was based on a desktop VR approach, while the second generates a complete immersion of the player in the virtual environment using a HMD.

Due to the specific needs of our target users, the chosen approach pays particular attention to providing sufficient scaffolding to each player to enable him to solve the given tasks and keeping the error rate as low as possible.

Scaffolding refers to the support given to the student in performing a specific task, which is beyond his reach independently (Bottino et al, 2011). It will allow the player to go through the game levels with the feeling of being able to solve the tasks, maintaining a good level of satisfaction and motivation. Scaffolding will have to be tailored to each single player in order to make the game difficult enough to be challenging and motivating, but easy enough to be solved in order not to disappoint the player and, at the same time, keep the error rate as low as possible. As the player's capabilities increase, the level of scaffolding is lowered until the he reaches complete autonomy in performing the requested tasks.

At the initial levels, the player is asked to move and take the avatar's perspective. Later, he can still move freely but has to be in the play position to answer. At the final levels, movement is always permitted, but the score is decreased, so that the best performance is obtained when the player can answer without any support. Game configuration allows personalizing the pace through the game to the player's needs.

Keeping error rate down is, as suggested by the "Errorless Learning Approach" (Terrace 1963), a way to make learning easier and quicker since there is no concurrent stimuli by errors. If an error is not recognized as such, it could be encoded into memory, and result in wrong responses later or conflicts between the correct and the erroneous information.

When the correct answer is chosen, positive feedback is always given and the player's score increased. When a wrong answer is given, the game provides specific clues in order to help the player understand his mistake. Furthermore, the presence of the tutor allows human intervention if needed. The game can always be paused and specific explanations given.

The games also include data mining to allow both having a detailed evaluation of the game itself and, as the game will be used by more people, studying the performance of a big population and defining general guidelines for its use.

3. First development: The "Smart View" game

The game has first been developed to be used with either a desktop pc monitor or an interactive touch table (Bottino et al, 2014). In this case, a virtual world is represented, but the player is not completely immersed in it, but he just looks at the scene from the outside. In the Smart View game, some objects are placed randomly on a virtual table as shown in Figure 1. The number of objects and their placement depend on the level of difficulty. On the screen, the game shows four different views of the table from the four sides. The player is then asked to choose one of the four possible answers according to the given task.

Before the game starts, some familiarization tasks are given. At the beginning, the player can move around the table to see how the scene changes. Each time he moves to a specific side of the table, by pressing a button he can change the view to the correct one. The different sides of the table are identified with different colours. The second familiarization task asks the player to choose, among the possible answers, the one that shows the table as he sees it, from his current position. The player is then ready to face the next levels, which are designed in order to promote the development of the embodied self-rotation.

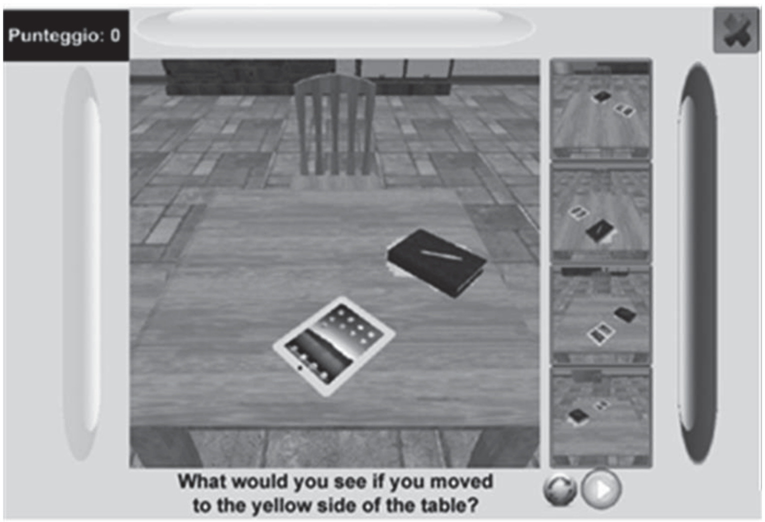

Figure 1: The Smart View game

The tutor plays an active part in the game. At first, he moves to a side of the table (e.g. the yellow side) and then the game askes "What would the tutor see from the yellow side of the table?". In this manner, the game suggests the player to imagine himself in the tutor's place before choosing the answer. Later on, the tutor stands back and the question is "What would you see if you moved to the yellow side of the table?". The second task is more difficult because the player has to imagine himself at the specified position without having the possibility to identify himself with the tutor's body.

In this version of the game, the mental rotation skill is also directly addressed by another set of tasks based on a round table that can be turned. At the familiarization level, the table with some objects on top is presented randomly rotated, and one image, showing the table from a different angle, is presented. The task is to rotate the table until the player's point of view matches the picture shown. The following tasks ask the player to rotate the table up to a position in which the shown picture represents what is seen from another side of the table. Again, two different tasks are possible: one in which the tutor actually occupies a position around the table, the other one in which the player has to freely imagine himself in the correct place without the body of the tutor giving him any suggestion.

4. Second development: The "In Your Eyes" game

Figure 2 shows the second version of the game, developed in an immersive VR environment. Compared to the first version, the focus of the game is on the first exercise: the table cannot be moved and the player is asked to point to the image on the wall that shows what the table would look like from another point of view.

In Your Eyes takes place in a virtual home environment. The player, at the beginning of the game, is standing in front of a table on which some objects have been placed. He is always free to move, explore the room he is in, and observe the scene on the table from any possible angle, just as if he were in a real world. Only when he is ready to play will he decide to tell the avatar to start the game.

Figure 2: The In Your Eyes game

An avatar is always present and interacts with the player giving him instructions and feedback as needed.

The aim is training the player to take the avatar's perspective by asking him which of the screens on the wall represents what the avatar actually sees on the table. The game is organized in different levels starting from a very easy task and gradually moving to the most difficult one.

At each level, several scenes can be played. Each is randomly defined with respect to the objects that are on the table, their position and rotation. A correct answer will give the player a score, which is reduced each time there is an error or an exploration within a task. When the player reaches a certain total score, he automatically moves to the following level. All thresholds can be manually changed by the tutors according to the needs of each player.

At the first level, the player is simply asked to say which of four screens on the wall shows what he is seeing on the table. This level is meant to facilitate understanding of the game mechanics by making the association between an image on the wall and what is seen on the table.

The next levels, gradually, lead the player to change his point of view with that of the avatar. At first the avatar walks near the player and simply asks him which screen on the wall shows what they both see on the table. Then the avatar walks to one of the other three sides of table and asks the player to reach him. When they are both on the same side, the avatar asks the player what they both see on the table. The player is forced to walk from his position to that of the avatar and, while doing so, he will see the objects changing.

In the following level, again the avatar moves to one of the three free sides of the table, but the player has to answer from his position without moving. Since mental rotation is an embodied process, and it has been shown that imagining oneself moving around the table actually helps in detecting the correct answer, the avatar suggests this strategy to the player by asking him "Imagine to walk around the table to my position, what would you see on the table? Which of the screens on the wall shows what you would see?"

Finally, at the last level, the avatar, placed at one of the sides of the table, simply asks, "Which of the screens on the wall shows what I see on the table?" The player is, at this point, free to use the strategy he prefers to answer.

The game is completely configurable on a personal basis, so if a player needs to stay longer at a specific level, the tutor can change his configuration file accordingly and keep him at the specific level as long as needed.

At any moment, the player can move from his playing position and walk freely in the room. In such a way, whenever the player feels that he needs to analyse the scene better, he can do so.

When the correct answer is chosen, the avatar gives a positive feedback. When faced with a wrong answer, the avatar switches off the corresponding screen and focuses the player's attention on the other possibilities.

5. Discussion of the development choices

It has been demonstrated that perspective taking is an embodied process. The first version of the game: Smart View, has been developed in a desktop VR environment, the objects on the table are actually seen as images and cannot not be perceived as "real" objects. Furthermore, moving around the table can only be done by clicking a button, which causes the scene on the screen to change to the new perspective. We felt that giving the player the possibility to actually walk around the table and look at the objects from all the possible angles would have been very helpful.

Another weak point of Smart View is the tutor's involvement in the different tasks. Tutors are not always trained to manage the game correctly, and even if they guarantee a more personalized approach to the games, this jeopardizes objectivity. Data collected on the use of the game would be influenced by the interaction with the tutor and the analysis on the usability and effectiveness of the game would not be possible.

For these reasons, a second version of the game has been developed in a completely immersive VR. Due to its reduced costs and ease to interface with Unity 3D, Oculus Rift (Oculus VR, 2015) has been identified as a possible solution.

Before opting for Oculus Rift, a short experiment has been done in order to evaluate the real usability of such a device with our population. A small group of nine intellectually impaired young adults has tried to wear Oculus Rift and move around a virtual town for some minutes. The outcome has been rather promising: most of the involved people showed interest in the device, managed to wear it without major distress and actually said to have enjoyed the virtual world. Only two people showed distress and took Oculus Rift off their head before the end of the experiment.

According to these results, we have decided to proceed with the development. Nevertheless, since the tool may not always be available and some users have problems in wearing the HMD without being sick, the game can also be used on a common computer screen. In this case, the mouse is used to manage all the movements of the player.

When Oculus Rift is used, the image is mirrored on the computer screen so that the tutor is always aware of what the player is seeing and doing. This is useful for the following reasons:

- Controlling the players' activity and motivation. If the tutor sees that the player loses interest in the game, he can decide to step in according to the single player's needs and characteristics.
- Helping the player in case he should be stuck in the game.
- Understanding if the player gets too tired or stressed by the use of the HMD and stop the game.

The player's head movements are detected directly by Oculus Rift, while the forward movement can be detected in a couple of different manners: with the use of a common computer mouse, or with the Wii mote control. Should the player have problems in moving around the virtual environment, the tutor can always move him around using the keyboard.

While the player is immersed in VR, all his interactions are limited inside the virtual world. He can move around in the most natural manner and all the needed instructions are given by the avatar. The interaction between the player and the game is designed to be managed by a voice recognition device, but no such system has yet been integrated. The target population we are going to test the game with will mainly focus on Down syndrome and some of them have speech difficulties, which would cause the automatic voice recognition to make several errors. Misunderstanding from the game would cause disorientation in the player and drop of motivation. Since the tests are planned to be carried out with the constant presence of a tutor, he can translate the player's commands by pressing a key on the keyboard. This choice has no impact on the player interaction with the game; he can speak freely and see the game reacting accordingly without being aware of presence of the tutor.

6. Conclusions

In this paper, we have described a game, whose objective is to support the development of some basic spatial skills that are needed for urban mobility of young adults with mild intellectual disabilities. The described game has been developed in two different versions: in desktop VR and an immersive VR.

Among the spatial skills addressed, the perspective taking ability has been proved to be based on embodied processes, which can be more easily trained in an immersive VR. The presence of an avatar offers a human body the player can identify with, and the free movement in the virtual room allows the exploration of the scene and suggests the strategy to be used to answer to the game tasks. Furthermore, the deep similarities of the VR with the real world tend to facilitate learning transfer.

On the other hand, using a HMD can be tiring and cause sickness to some learners. Furthermore, the virtual room can draw the attention away from the main task of the game and influence negatively the players' learning.

An experimental evaluation of the two games will soon be carried out with a group of intellectually impaired young adults who have already developed some basic spatial abilities and have the possibility to develop, at least in part, some spatial perspective taking skills.

A specific assessment of the users' skills with respect to mental rotation and perspective taking abilities has been defined and will be used before and after the planned training sessions. Furthermore, questionnaires and monitoring sheets will be used to collect the users' reactions and appreciation at each session of the game.

At the end of the test, all the collected data will be analysed with the aim of giving an assessment of the skills learnt, the ease of use of the games and the main differences between the two VR approaches.

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Game-Based Learning for Youth Career Education With the Card Game 'JobStar'

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Abstract: Rapid advancement in science and technology drives social change in various ways. While computerization has enhanced our work's productivity, recent research foresees a high probability that computers and robots will replace workers in many jobs, such as telemarketing, hand sewing and watch repair, in the near future. Career education for youth is a crucial social issue and must be updated to prepare for future social needs. Current job search tools based on a self-analysis test tend to be serious; it is difficult to change a job seeker's viewpoint from current job opportunities to future possibilities. The present situation in career development is emotionally unhealthy for youth, and it is necessary to create more opportunities to help them build a positive attitude towards their profession. This study aims to help youth advance towards a better career by developing and implementing a card game for career education called 'JobStar'. The game is easy to apply to a normal classroom setting and positively and playfully involves students in discussions regarding future jobs. The game requires participants to analyse social issues and articulate future job needs. A game-based career education workshop was conducted to evaluate the impact of the game activity on participants. Results of a pre- and post-survey for participants indicated that the game offered an engaging opportunity that enhanced social interactions and facilitated participants' learning from each other during the game play. Participants gained a positive attitude regarding their future paths. Their experience with the game made them more confident about their competence in choosing their occupations. The game created a playful context for thinking about a serious topic that youth tend to be reluctant to consider and supported participants in practicing idea generation and verbally presenting their ideas by promoting interaction among participants.

Keywords: career education, card game, serious games, game-based learning

1. Introduction

Social and environmental changes such as globalization, climate change and demographic changes are influencing how we develop jobs for the future. Rapid advancement in science and technology drives social change in various ways. While computerization has made our work more productive, recent research foresees a high probability that computers and robots will replace workers in numerous jobs, such as telemarketing, hand sewing and watch repair, in the near future (Frey & Osborne 2013). Simultaneously, various new jobs have emerged such as data science and website design which did not exist previously. A survey which estimated that 65% of today's grade-school students may end up doing jobs that have not yet been invented, has attracted public attention (Davidson, 2011). Although it is difficult to foresee future circumstances, people in both the public and private sectors consider career education for youth a crucial social issue, and it must be updated to prepare youth for future social needs.

In Japan, there are many governmental initiatives to support youth career development in schools and elsewhere. For example, the Central Council for Education recommended that the Ministry of Education, Culture, Sports, Science and Technology improve career education and vocational education in schools (Ministry of Education, Culture, Sports, Science and Technology of Japan, 2011). The Ministry of Economy, Trade and Industry of Japan conducted a survey to understand the industry's needs for human resources (Ministry of Economy, Trade and Industry of Japan, 2013). It has been suggested that a joint collaboration between educators and industries would create more opportunities for improving career education. Various approaches regarding this issue have already been attempted, such as inviting professionals as guest speakers at a career education seminar, an internship program at a local company enabling students to possess work experience and the hiring of a career education coordinator to plan and implement education programs with local businesses. However, these efforts have tended to focus on matching youth with current human resource needs and do not necessarily consider ongoing social change and the jobs of the future. The Canadian Scholarship Trust Foundation is making efforts to consider such concerns about the future for youth career education. Their Inspired Minds Careers

2030 initiative provides a list of new jobs composed by researchers and futurists which may appear in the next 10 to 20 years (CST, 2014). It is expected that current jobs are also going to be updated to address social changes. Although these efforts offer rich sources of information for helping young people think about their future professions, most of these programs tend to heavily rely on delivering information, such as lectures and texts. Current job search tools based on a self-analysis test tend to be serious, and it is difficult to change a job seeker's viewpoint from current job opportunities to future possibilities.

The premise of this study is that career development activity can be more casual and playful so that students are able to think about their future occupations more positively. College students in Japan tend to experience high anxiety during their job search period. Few of them even become depressed, and each year, some even commit suicide. The present situation in career development is not emotionally healthy for youth; hence, it is necessary to create more opportunities to help them build a positive attitude towards their career.

2. Development of the game 'JobStar: Create your star job'

2.1 Overview of the game design

There are several entertainment games themed on the life of people such as 'The Game of Life', 'CV (Milunski, 2013)' and 'Career Odyssey (Franklin Learning Systems, 2008)'. These games may provide players with some life lessons that they may have never experienced (Canary, 1968). However, such games tend to treat jobs as stereotypical and unchangeable. Even though game-based learning is considered as a possible tool for career education (Miller and Knippers, 1992), it is not studied sufficiently to fully understand how it can be used. While there have been a few attempts at utilising simulation games for career guidance (Fukamachi 2006; Fukamachi 2010), in such simulation type of games players tend to see existing jobs as model and hardly view other jobs that do not exist currently. To encourage the youth to think about their future more positively, we assumed that it may be effective to engage them in a game- based activity to think about their future 'out-side-the box'. Therefore, we developed a card game for career education, called 'JobStar', to help youth to foresee their future occupations. The game is designed to be easily applied in a normal classroom setting and to engage students more positively and playfully in discussions regarding future jobs.

The basic theoretical background employed in the game design is Bandura's social learning theory (Bandura 1997). Bandura conceptualized the characteristics of learning in a social context with the terms 'social modelling' and 'vicarious learning'. He emphasized the importance of surrounding oneself with other people when learning, as this brings another layer of meaning to the context. Peers learn from each other through interaction in various ways. Observing a peer's actions is one way and collaborating with peers is another. In this game, players are not only required to present their idea but also have to listen to ideas from others for several times. Although a player may be unable to comprehend the game initially, he/she can immediately play comfortably by looking at other players and learning to play. This game utilizes this advantage of playing games in a social context.

The main target users are high school students and college students who have started thinking about their future path. The game can also be used for working adults and elders who are concerned with career development. The game is designed as a card game that can be played with three to five players. The game package comprises 20 'Job Cards', 20 'Events Cards' and 16 'Industry Cards'. Each Job Card contains a generic job type such as 'engineer', 'designer' and 'guide', with a brief description of the major roles of the job. We chose the jobs based on information from literatures and websites that are widely known by Japanese youth (Murakami, 2003; Benesse, 2014). Among the hundreds of jobs existed, we selected generic popular jobs that are simple and applicable to many industries. The appropriateness of the selection was tested by prototype play tests during development. The Event Cards illustrate issues and incidents that are considered likely to occur in the near future; for example, 'global economy', 'national financial collapse' and 'robotization'. The Industry Cards describe major industries such as 'finance', 'information and communications' and 'health care'. Figure 1 demonstrates an example of the card design. In addition to these cards, a game board and 'Good Job' tokens that are awarded to the winner are included in the game package (Figure 2).

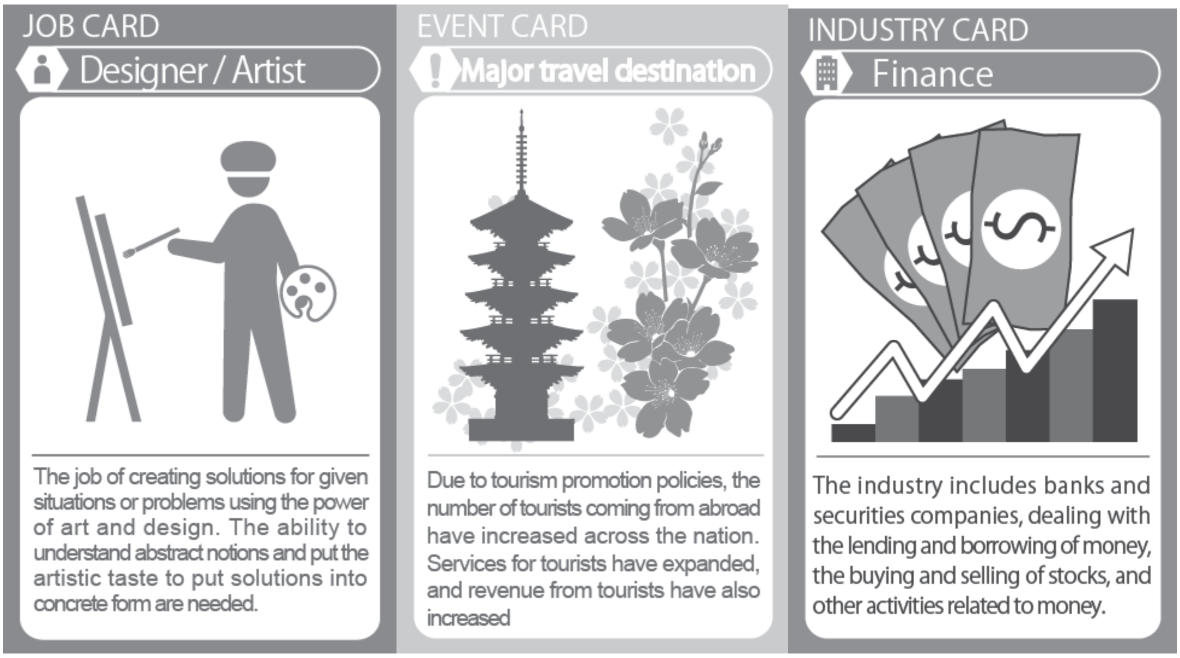

Figure 1: Examples of JobStar playing cards

Figure 2: The game materials of JobStar

2.2 How to play

During the game, players have to come up with a unique job name based on the Job Cards that are provided to them and present a job profile and how the job might be needed in a certain context in the future, as described on the Event Card and the Industry Card. The process for playing the game is as follows:

- Before play begins, all players (when there are four players) are provided with five Good Job tokens. The Industry and the Event Cards are shuffled and placed on the board. The Job Cards are shuffled, and each player is dealt the same number of cards (five cards).
- Each player is allowed to draw an Industry Card and an Event Card and place them on the round's zone. Each player looks at his or her hand and considers what type of job is needed in the industry if the event occurs that is described on the selected Event Card. Each player creates a new job type based on one of the Job Cards he or she is holding. For example, the player might draw the 'Shrinking and ageing population' Event Card and the 'Transportation and shipping' Industry Card, and then they would have to imagine a society in which revitalization and increasing productivity have become an issue due to the decreased number of young workers. They then have to think through and create a new type of job that is needed in the transportation and shipping industry based on the Job Card in a player's hand.
- When a player comes up with a new job type, he or she places the Job Card on the back and waits until the rest of the players are ready. When all the players have placed their cards, they randomly determine which

player will go first. The player who goes first states the new job type that has been created and describes the significance of the job in the given context.

- The players take turns delivering their presentations, and each player votes on the best job creator of the round with the Good Job tokens at the same time. The number of tokens collected by each player represents the points gained in the round.
- At the end of the fifth round, the player who gains the most tokens wins and is awarded the title of 'Star Job Creator' of the game.

The standard length of playing time is approximately 45–60 minutes; therefore, the game can be used in a school classroom or a short training session. By playing the game, players are required to think about social issues analytically and articulate future job needs in a short period.

3. Method

3.1 Participants and materials

To examine the effectiveness of the game, we designed a game-based career education workshop for university students and held an experimental session to evaluate the impact of the game activity on participants in December 2014. Nineteen undergraduate and graduate students (n = 19, 12 males and 7 females) participated in the workshop. Participants were divided into five groups of three to four people and played the game in the workshop session (Figure 3).

A set of pre- and post-survey questionnaires based on a five-point Likert scale (1: totally non-applicable to 5: totally applicable) was utilised to collect data, to explore how participants felt about the game and how their experience in the game influenced their individual views on their future career path. At the beginning and the end of the workshop session, participants were asked to answer the questionnaires in terms of (1) feelings of anxiety and self-confidence on career decision-making self-efficacy (Urakami, 1994) (16 questions for pre- and post-survey); (2) a sense of engagement in activities (Fukamachi, 2006) (three questions for pre- and post-survey); and (3) impressions regarding the game play (10 questions for post-survey).

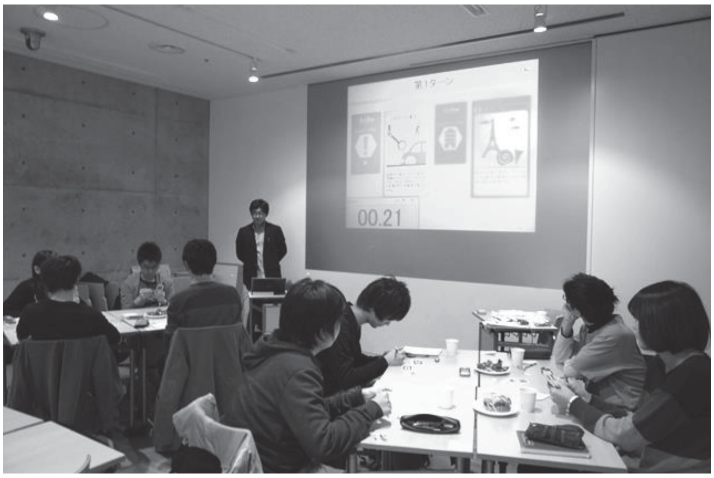

Figure 3: JobStar workshop session

To control the game conditions, the Event Cards and the Industry Cards were predetermined by the researchers, and all groups attempted the same challenges with fixed combinations of cards under the moderation of the researchers (Table 1 shows the set of cards used in the session). The Job cards were randomly dealt in the group. In between rounds, the players shared the results with other groups and had group discussions to reflect on the game play.

Table 1: Set of cards used during the workshop session

	Event Card	Industry Card
Round 1	Spread of robots	Tourism and food
Round 2	Advancement of women	Telecommunications
Round 3	Collapse of national finance	Beauty and fashion
Round 4	Globalization	The farming, foresting and fishing industries

	Event Card	Industry Card
Round 5	Major travel destination	Education and child care
Job Cards	Designer/Artist, Planner/Coordinator, Researcher, Engineer, Analyst/Consultant, Trainer/Coach, Chef/Cook, Guide, Driver/Pilot, Doctor/Nurse, Athlete, Scientist, Therapist, Buyer/Dealer/Sales, Writer, Programmer, Companion/Communicator, Teacher/Instructor, Operator/Technician, Agent	

Students came up with various new jobs. In Round 1, for example, a participant created 'Trip Designer', a person who designs an exciting tour by utilising various types of robots to enhance the value of the tour. In Round 2, another participant presented a 'Mom-Help Programmer', a specialist who focuses on developing application software to assist working mothers. Each group came up with 15–20 new jobs and reflected on their own career goals based on the jobs they created. Although some players play the game for fun, they still play with actual information on jobs and social issues. While players can play the game simply to think of fun ideas, such ideas could also stimulate other players to think differently. The part of Reflection plays an important role in gaining insight from the gameplay.

4. Results and discussion

4.1 Impression of the game play

The participants responded to 10 questions regarding their views on the overall experience of the game. The results indicated that the participants found the game quite satisfactory overall (Figure 4). According to the responses, most students found the game fun to play (Q1), and they found the game easy to be involved in (Q2). Although the game activity was difficult (Q3), they enjoyed communicating with the other players (Q4); most participants found the game activity engaging and did not feel like studying at school (Q5, Q6) and wished to play the game again (Q10). These responses imply that the difficulty of the activity did not disrupt the fun of playing. The game seemed to offer participants an opportunity to think about future jobs (Q9) and enabled them to learn from others' ideas while enjoying the personal interaction, which they found encouraging (Q7, Q8).

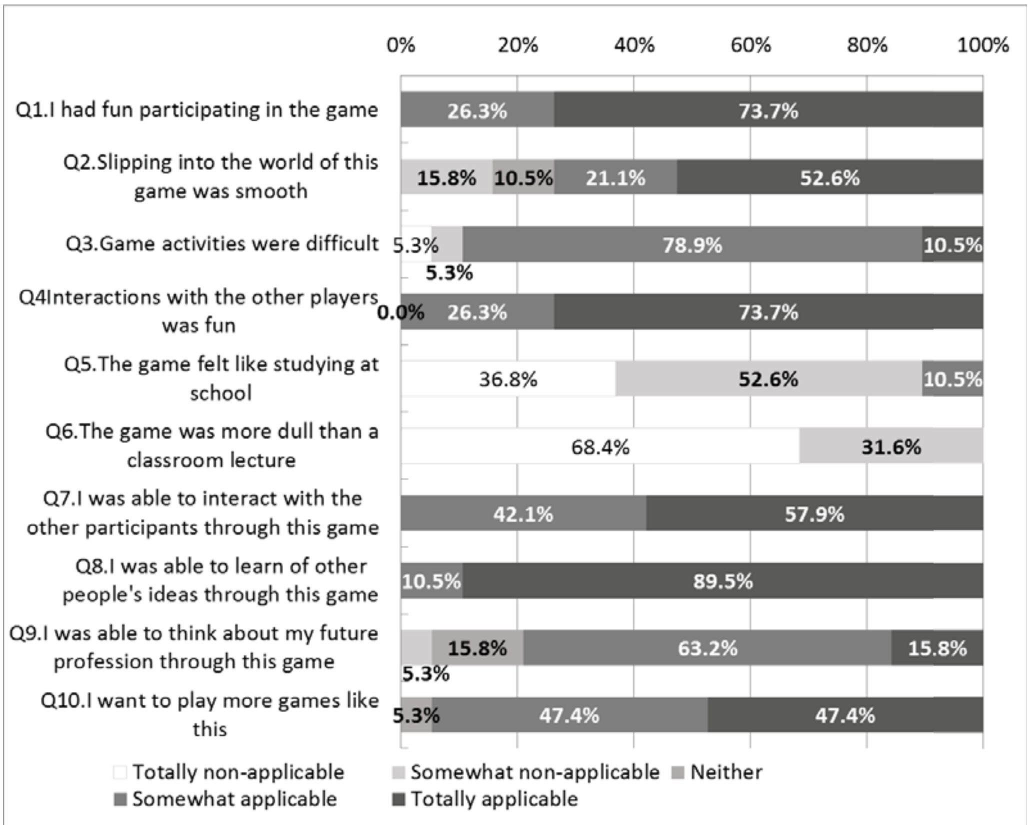

Figure 4: Feedback from the workshop's participants

Following are the comments from the participants on how this game offered them a positive experience:

'By thinking about the future playfully, I felt my anxiety somewhat removed! I noticed that I have been thinking my career in a short sight. I should have a viewpoint to look at ten to twenty years after in Japan for my job search'. (Participant x-x)

'I felt I got more materials now to think about my career like "I should come up with a good plan if I get a job at IT company"… It was a new game experience. As I don't usually think like this, I was stumped, thought out woefully and got an idea out of the box'. (Participant x-x)

4.2 Views on future path and competency to think about future

The participants answered questions regarding their overall views of their future and confidence in their competency to think about the future. While there was no significant difference on most of the questions, responses to some of the questions indicated that the participants may have changed their views about the future and gained confidence in making career decisions after the game play. A comparison of the results from the pre- and post-survey data with a paired t test indicated that more participants tended to think that they have future goals and are more confident in imagining and deciding on a future profession based on their talent. Additionally, the students generally felt that they could listen to others (Table 2).

Table 2: Students' views on future path and competency to think about the future

	Mean		Std.		t-value
	Pre	Post	Pre	Post	
Q2-1. I have my future goal.	3.11	3.53	1.370	.964	-2.388 *
Q3-1. I have confidence in understanding my competency.	2.32	2.89	.946	1.049	-3.012 **
Q3-2. I can imagine my ideal future job.	2.78	3.44	1.166	1.149	-3.117 **
Q3-3. I can decide my future path in which I can effectively utilise my talent.	2.61	3.33	1.037	.970	-3.424 **
Q3-7.I can listen to others carefully while they are talking.	4.17	4.44	.383	.511	-2.557 *
*p < .05, **p <.01					

The game content is not entirely entertaining, as it involves serious social issues and information regarding job descriptions and industries, which are not significantly different from the contents of a social studies textbook. Thinking about a job is not an immediate activity for youth, who have concerns because they have experienced painful and discouraging stories about job seekers in the news media. However, during the game, participants were engaged in conversation with others about future jobs and enjoyed playing with the contents, including the reference to serious matters, and thereby gained a more positive attitude. The following comments reflect such a positive change in the participants:

'I tend to feel anxious when I think about my future, but the game made me think that there are lots of possibilities we have! Even though it is not actually existed, we can do lots of things to address needs in the future'. (Participant B-1)

'Other than the jobs I preferred, I noticed that it is possible to create those that are needed in society by changing our views'. (Participant C-4)

It is expected that these types of notions that the participants gained from the game play may influence their views on actual job search activity as well as career development in the long term.

5. Conclusion

The game offered an engaging opportunity that enhanced social interactions and facilitated participants' learning from each other during the game play. The results of the survey revealed that participants gained a positive attitude about their future paths. Additionally, it was indicated that their experiences with the game made them more confident about their competence in choosing a profession. The game created a playful context for thinking about a rather serious topic that youth tend to be reluctant to consider. It also supported participants in practicing idea generation and verbally presenting their ideas by promoting interaction among participants.

As the data was collected from a limited number of participants in an experimental workshop session, the results did not provide concrete evidence that showed the effectiveness of the game for career education. Further extensive research on a larger population, possibly on an international scale, is required to understand the effectiveness of JobStar. While the results are still preliminary, the study indicated that the game can work as a tool for enhancing interaction among game players and facilitate reflection on their future jobs in a playful manner even though the theme itself is quite serious.

To expand the usefulness of the game, we will continue to improve it and establish it as a model of a game-based career education tool that offers youth the opportunity to imagine their future path positively. For example, the Good Job Tokens feature was not shown to be as effective as we considered. It could be improved to enhance the fun of the gameplay. We also noticed that the game rules can be modified to help novice players easy entry into the game (e.g. omitting Industry Cards at earlier rounds to balance complexity). Based on the study, we have produced the English version of JobStar to introduce the game to the players worldwide. It is expected to gain more play data from non-Japanese player to assess how the game works for various audiences.

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On the Development of Constructivist Educational Computer Card Games: The CLASS-Platform

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Abstract: This paper introduces the design of "CLASSification" (CLASS); a web-based platform for the development of single-player, classification-based Educational Computer Card Games (ECCGs) by non programmers – educators, and students. Within CLASS, they would have the opportunity to create their own ECCGs for the learning of specific disciplines, across several learning subjects and educational levels, using a simple and user-friendly "setup environment". CLASS also provides opportunities for the design of ECCGs using modern social and constructivist theories of learning, in combination with basic game design principles. Specifically, the "7-step modeling methodology" for the design of constructivist ECCGs (Kordaki, 2015) was taken into account during the design of this platform. Based on the aforementioned methodology, the content of various types of cards need to be set by the designer according to the learning subject that the ECCG will be used for, namely: (a) cards related to the learning subject in question, (b) motivation cards, (c) challenging cards (to help students clarify their non-scientific conceptions), (d) scaffolding cards, and (e) information about the game cards. During the design stage, educators/designers should have in mind, the common learners' misconceptions related to the learning subject in question. Learners are asked to play with the aforementioned types of cards, featuring both figures as well as textual statements. Players/learners have to make appropriate classifications – according to specific concepts/criteria defined by the educators during the design stage – by forming valid groups of cards. By playing this type of ECCGs, students are supported to develop various cognitive and critical thinking skills, such as: Observation, recognition, knowledge recall, comparison, classification, identification of relationships among entities as well as analysis of the structural elements of a group and synthesis of valid groups of entities. To clarify both the design-mode and the play-mode of CLASS ECCGs, a brief example of an ECCG about nutrition education is presented.

Keywords: educational computer card games, platform, classification, educators, cognitive skills

1. Introduction

Educational Computer Games (ECGs) represent a modern educational approach that is emerged due to the pervasiveness of gaming, the universal use of the Internet and the necessity more engaging educational practices to be developed (de Freitas & Liarokapis, 2011). In effect, learners' motivation and engagement could be enhanced through meaningful activities where gaming and learning are combined (Shaffer et al., 2005).

Among the main features which characterize ECGs as high quality learning environments, are their interactivity, the user-centered design, and their ability of immediate feedback (Winrow, 2013). In addition, ECGs have the potential to be effective tools for the learning of hard and complex matters because they could: (a) enable learners' action instead of asking them for explanations, (b) create personal learner motivation and enjoyment through interesting and meaningful activities, (c) support multiple learning styles and skills enabled by different game types and features, (d) reinforce mastery skills through the engagement in game-play, and (e) provide an interactive and decision-making context (Kebritchi & Hirumi, 2008). Consequently, ECGs could have positive impacts on players'/learners' development integrating a number of different skills (Susi, Johannesson & Backlund, 2007) such as: analytical and spatial skills, strategic skills and insight, learning and recollection capabilities, psychomotor skills, and visual selective attention (Mitchell & Savill-Smith, 2004).

ECGs could also reinforce an innovative learning process by adopting a learner-centred perspective where educators act as facilitators (Arnab et al., 2012). Here it is worth mentioning that, the educators' role is significant since they need to explore innovative ECG-based teaching/learning strategies, (Ratan & Ritterfeld, 2006), select appropriate ECGs and integrate them in the form of structured learning activities, guide the unfolding of those activities and facilitate learners' actions (Arnab et al., 2012). However, it seems that not all educators know how to integrate ECGs in the learning process (Shaffer et al., 2005); they might find hard to identify the way a particular ECG is relevant and appropriate for the learning of a specific subject of the curriculum or – due to time-limitations – they can't get acquainted with the ECG at hand and the proper teaching methods so as to attain the best learning results by its use (Gros, 2007). Therefore, educators are usually unwilling to use ECGs as learning tools although they are aware of their positive effects towards learning (Gros, 2007; Kirriemuir & McFarlane, 2004).

To override the aforementioned obstacles, an innovative approach that promotes the idea of "educators as designers of ECGs" has been suggested (van Eck, 2006; ProActive, 2010). By designing ECGs, educators would stop being reluctant in the use of them as they could integrate specific games in the learning process; games that are curriculum-oriented, related to certain teaching objectives and appropriate for their students' needs. Actually, educators would not have to worry about curriculum as well as about technological and financial limitations and they would be able to use them in every detail, since they would have designed them and would be acquainted with them, too (Osman & Bakar, 2013). However, in order to realize this approach, major obstacles should be overcome which are mainly due to the educators' lack of the required knowledge to develop computer games (van Eck, 2006; ProActive, 2010). A possible solution could be the introduction of simple-to-use authoring environments for the creation of ECGs by non computing majors – educators and students (Torrente et al., 2008). Within these environments, educators would also be able to support learners to design and develop their own games.

As far as card games (CGs) are concerned, they are simple games (Crawford, 1982), which are focused on card combinations that are formed by the players taking into account the specific card-characteristics in conjunction with probability, classification, grouping, comparison and matching issues. Actually, classification activities are central to CG play as players understand the learning concepts in question by creating appropriate groups of cards, thus, critical thinking, reflection and problem-based learning is promoted (Kordaki, 2015). Due to the fact that CGs contain simple equipment and rules, they could be employed as the starting point for novice players in order to be motivated and engaged in the game-based learning experience (Gosper & McNeil, 2012). CGs also could be used to promote the enforcement of matching, number manipulation and pattern recognition skills (van Eck, 2006); at the same time they could encourage the players' logico-mathematical and interpersonal intelligence (Berger & Pollman, 1996). In addition, the first four levels of Bloom's hierarchy of learning outcomes are best associated to CGs (Sherryl & Pachero, 2006).

As far as educational computer CGs are concerned, in several cases new potential for learning and e-learning have emerged through the adoption of new modalities of interaction during CG-play while the innovative pedagogical approaches that were taken into account in the design of several ECCGs seemed to contribute to the learners' knowledge construction (Kordaki & Gousiou, 2014). In addition, constructivist methodologies have been suggested for the design of ECCGs acknowledging problem-solving and students' misconceptions (Kordaki, 2015). ECCGs were also used in primary and secondary education to enhance and support learning in various disciplines, namely, computer science, mathematics, science, languages, health, and history (Kordaki, 2011; Gousiou & Kordaki, 2015). Moreover, virtual flashcards - created by students and educators through free applications, such as FunnelBrain (www.funnelbrain.com), Flashcard Machine (www.flashcardmachine.com), Quizlet (quizlet.com) - have been used in recall-based activities for the learning of any subject. However, it has not yet been suggested a platform based on a constructivist pedagogical framework for the creation of ECCGs – focusing on classification activities. It, is also worth to mention, that the contents of the constructed ECCGs – using the aforementioned platform- could be easily adapted in any subject of any discipline by non-computing majors while after game-play educators could be also provided with useful feedback related to the players'/learners' performance and misconceptions.

Thus, taking into consideration the aforementioned issues, a platform – entitled "CLASS" (CLASSification) – that supports the creation of adaptable customizable classification-based ECCGs, for any specific learning subject by both educators and learners who are non-computing majors has been designed and is presented in this paper. This is the contribution of this study. Classifying/categorizing is the act of grouping items in categories on the basis of their attributes. It is an essential cognitive skill as the world consists of an infinite number of stimuli and through classification people make unfamiliar things familiar as they link the new information to known categories, thus, the comprehension and retention of information could be facilitated (Marzano et al., 1988). The ECCGs constructed using CLASS, could support learners to clarify a number of essential aspects/concepts of a specific learning subject or they could be even suggested for interdisciplinary approaches. The design of CLASS is based on a constructivist modeling methodology.

In the next section of this paper, the design methodology of CLASS is presented, followed by the occurred ECCGs' pedagogical value along with the educators' and learners' role as designers of these games. Next, the operations which are available for the designers and the players will be presented accompanied with an example of the "Nutrition-CLASS", an ECCG designed for the learning of basic aspects related to nutrition education. Finally, a summary of the work is presented and future research plans are drawn.

2. The design methodology of the CLASS CCG platform

The CLASS platform provides opportunities for the design of CLASS computer card games (CCGs) based on modern social and constructivist theories of learning, in combination with basic game design principles. Specifically, the "7-step modeling methodology" for educational constructivist CCGs (Kordaki, 2015) was taken into account. According to the aforementioned methodology the following 7-steps should be taken.

- *Step 1:* During this step, the definition of two models needs to be realized, namely: (a) *the model of the learning subject*: The fundamental concepts/aspects of the learning subject in question have to be determined by the designer of the CLASS CCG at hand. Based on this model, a number of fundamental aspects (FAs) that could be learned by the players through CCG-play should be clearly identified, and (b) *the learners' model:* The learners' non-scientific conceptions regarding the above mentioned FAs need to be determined, taking into account literature reviews or appropriate empirical studies, in order to be surpassed during CLASS CCG-play. Besides, the representation of both learning subject and learners' models in a concept map might be beneficial for the designer, so as to design a complete game for a specific learning subject (Kordaki, 2015).
- *Step 2:* Based on the aforementioned models, the *aims of the CLASS CCG* for the subject in question should be explicitly defined.
- *Step 3:* In this step the definition of *the learning model should be realized,* emphasizing the role of appropriate CG-play *learning activities*. In fact, CLASS CCG-play encompasses: (i) card classification activities, including grouping of appropriate cards and rejection of the non-appropriate ones, and (ii) asking/answering appropriate questions where players/learners have to identify the features or attributes of entities of the FA in question, and provide right answers. Hence, players/learners have to select the cards that are related to the FA in question and reject the other ones in order to form a valid group of them, while they also have to select the right answers of multiple choice questions.
- *Step 4:* Specific CG-play activities should be realized through Challenging-cards that address learners' common mistakes in order students to be supported to overcome their difficulties and misconceptions.
- *Step 5:* Motivation for students during CG-play is provided through appropriate Joker-Cards.
- *Step 6:* Appropriate information that could be used in case of learners' difficulty during CG-play is provided through Scaffolding-cards.
- *Step 7:* Definition of the CG rules is provided through Rule-cards.

Taking into consideration all the above, a deck of cards need to be appropriately designed. In fact, the deck of each CLASS CCG is consisted of 7 types of cards that have a specific role in the CCG-play. Specifically:

- (a) Figurative-cards: A specific number of Figurative-cards are designed illustrating representative figures for each FA in question.
- (b) Text-cards: A specific number of Text-cards are designed illustrating representative textual statements for each FA in question. During the card classification activity, players/learners should select the appropriate combinations of Figurative-cards and Text-cards featuring entities related to the FA in question so as to form a valid group of cards, in order to win.
- (c) Challenging-cards: For each FA a specific number of Challenging-cards are designed in order learners to be supported to overcome their difficulties and misconceptions about the FA in question, as these emerged from the learners' model definition. Figures and/or text referring to learners' common mistakes could be illustrated in these cards and they should be rejected by the player/learner.
- (d) Multiple-choice Question-cards: A number of Question-cards containing multiple-choice questions are also designed for each FA, in order players/learners to select the right answer and reject the wrong ones. The design of the multiple-choice questions is also based on the first two of the aforementioned models with an emphasis on the learners' misconceptions related to each FA.

- (e) Joker-cards: Several Joker-cards that fit to all FAs are designed in order to motivate players to be engaged in the CLASS CCG-play. These cards could illustrate figures and/or text that are related to the players' interests or they could illustrate axioms related to the FA in question and they could be used during the creation of a valid group of cards for any FA. On the whole, Joker-cards that appear randomly combined with an appropriate scoring scheme could enhance the players' motivation in the CLASS CCG-play.
- (f) Scaffolding-cards: A number of Scaffolding-cards, equal to the number of FAs, are designed in order players/learners to be supported, in case of a difficulty, with useful information (figurative/textual) regarding the said FAs. This information should be short but also comprehensive so that learners could be enlightened and supported in case of a difficulty, as they appear on players'/learners' demand.
- (g) Rule-cards: The rules of the CCG could be illustrated in Rule-cards. These cards should be brief and concise while they should be available at any time of the game.

For each FA all the above mentioned cards (except g) should be designed. Finally, a scoring mechanism should be defined in order to add adrenaline in the CLASS CCG experience.

3. Pedagogical value of the CLASS CCG

CLASS platform has been designed in order educators and learners to have the opportunity to construct their own CLASS CCGs adapted to specific aspects of a discipline without being computing majors. On the contrary, they have to use the CLASS platform for the construction of CCGs for specific learning subjects through a friendly environment while the resulting CCGs could be used, evaluated and enjoyed by the players/learners at school or at home. The CLASS platform provides diverse opportunities for educators and learners. In fact, educators can act as CCG designers while learners could act as designers but also as players.

Educators as designers of ECCGs: Specifically, CLASS platform provides educators with the opportunity to construct their own CLASS CCGs based on the curriculum and the learners' needs. Each CLASS CCG is customizable since it could be adapted to support the learning of any subject related to any discipline. It is also customizable, since educators could form the rules of the CCG as well as the entire card-deck taking into account the learning subject model and the learners' needs and misconceptions derived from the learners' model. Moreover, CLASS CCG provides educators with feedback through a "Summary report" for each learner that could be used for the evaluation of both: the learner and the CCG at hand. This report provides information based on the learners' scoring and selections reported in appropriate formulated log files. The aforementioned information could lead to the improvement of the CLASS CCG content as well as in the design of personalized learning activities exploiting the learners' misconceptions emerged during CCG game-play.

Learners as designers of ECCGs: From this perspective, the CLASS CCG construction process is a learning activity where learners could be actively engaged and develop critical thinking skills by facing challenges, limitations and constraints. In fact, learners initially have to comprehend the learning subject in question by defining the learning subject model in order to be able to determine specific FAs. At the same time, they also have to take into account the difficult aspects of the said learning subject so as to identify and gather the appropriate content, e.g. figures, multiple choice questions, scaffolding text and/or figures, so as to be able to create the appropriate deck of cards.

Learners as players of ECCGs: By playing with CLASS CCGs learners/players could be motivated to participate in a familiar learning activity as CG-play is. Moreover, learning could become more compelling and effective, since the rules of a CLASS CCG are simple, thus, players/learners promptly could be immersed in the learning activities and play without being distracted from difficult game rules. Through CLASS CCG-play, players could have also the opportunity to conceptualize and reflect on several aspects of the learning subject under discussion. Actually, learners have to establish the necessary concepts related to a new learning content in order to be able to comprehend more complex information (Marzano et al., 1988). Thus, through CLASS CCGs, learners have the opportunity to perceive the new learning content as essential part of the learning subject in question, to acknowledge its multiple dimensions and FAs, and to conceptualize it as an entity as it emerged from the learning subject model. Additionally, they could overcome their misconceptions related to each FA in question through the rejection of the Challenging-cards while they could be also staying in the CLASS CCG-play by laying on the supporting mechanism of CLASS using the Scaffolding-cards provided. In fact, during CLASS CCG-play, players/learners have the opportunity to:

- Observe the Figurative-cards and concentrate on the Text-cards in order to recognize the aspects of the FA in question by recalling their knowledge so as to infer and, thus, make both the appropriate classification of Figurative-cards and Text-cards and the rejection the Challenging-cards. In fact, making an inference entails recalling, comparing, and identifying relationships (Marzano et al., 1988).
- Reflect on their previous knowledge about each FA in order to: (a) give right answers to the multiple-choice questions illustrated in the Question-cards, (b) reject the wrong answers of the said Question-cards, (c) make the appropriate classifications of Figurative-cards and Text-cards about the selected FA, (d) reject the Challenging-cards of the FA in question, and (e) draw appropriate conclusions regarding the said FA.
- Identify the multiple aspects of a learning subject through dealing with the related essential FAs that have been considered during the design of the CCG at hand.
- Comprehend the commonalities of the FAs during the whole game play, by using appropriate and meaningful Joker-cards that can be used overall in the classification activities.
- Compete with themselves or other peers while playing each CLASS CCG.
- Collaborate with their peers through CG-play by recalling and reflecting on their knowledge in a meaningful way so as to use it for new learning experiences.

Overall, players/learners could be also motivated to play and stay engaged in the CCG activity as the necessary characteristics, namely: challenge, curiosity, fantasy, control, and feedback (Malone & Lepper, 1987) that enhance players'/learners' motivation are integrated in the learning activities of the CLASS CCG. Specifically: (a) challenge is promoted through the CCG's certain goals, uncertain outcomes, competition with peers, and the scoring mechanism, (b) the CCG experience is supported by imaginative contexts in the form of figurative parts and informative structures while curiosity is also provoked by them and also by the elements of surprise that occur by the randomness in the presentation order of the cards, (c) a sense of control is provided through the players'/learners' choices during the game-play (e.g. card selection or rejection, ask for Scaffolding-cards) in order to succeed, (d) informative feedback and support in the form of detailed messages and Scaffolding-cards, respectively, could also increase players'/learners' confidence.

Finally, during CLASS CCG-play, learners are supported to develop core critical thinking skills such as: information gathering, remembering, organizing, analyzing, and generating thinking skills, namely, observation, recognition, knowledge recall, reflection, classification, and identification of relationships among entities as well as analysis of the structural elements of a group and synthesis of valid groups of entities.

4. Educators and learners as designers of CLASS Ccgs

The CLASS platform is consisted of two distinct modes: the *design*-mode and the *play*-mode. Initially, designers/teachers have to setup the CLASS CCG and then learners/players have the opportunity of playing with it. In order both modes to be clarified; a brief example of "Nutrition-CLASS", a CCG designed for the learning of basic aspects related to nutrition education, is briefly presented.

4.1 Design mode

During the design of a specific CLASS CCG several essential actions should be taken by the designer of the game. Specifically, CLASS allows the designer to define the following necessary aspects for each CCG:

- The learning subject of a discipline the CLASS CCG is about.
- The educational level (pre-primary, primary, and secondary) the CCG is referred to.
- A number of FAs for the said learning subject based on the learning subject model and the learners' model as well.
- Deck construction: Based on the above, the CLASS CCG should be setup through the design of the appropriate card-decks. Specifically, a number of Joker-cards that are related to the learning subject in question should be constructed. These cards fit to any FA and could participate in the formation of any group of cards. The Rule-cards describing the rules of playing the whole CLASS CCG at hand should be also constructed. For each FA a different card-deck should be designed consisting of 7 types of cards, which have been described in details at section 2. Since Joker-cards and Rule-cards have already been designed as they can be used for any FA, the remaining 5 types of cards should be designed for each FA, namely: Figurative-cards, Text-cards, Challenging-cards, Question-cards, and Scaffolding-card. An example of the "Card-deck

design" screen is presented in Figure 1 where the card-deck for the FA – "The Food Pyramid and the basic composition of foods" – of the "Nutrition-CLASS" CCG can be designed.

- The scoring mechanism: During this phase the scoring scheme should be defined by determining how many points the player/learner: (a) earns/loses for each right/wrong grouping, (b) earns for each Joker-card that has been included in each formation, (c) earns/loses in the case of a correct/wrong answer, and (d) loses when asking to use the Scaffolding-cards for any FA. Time could be also a part of the score so that the total score for the CCG could be determined by combining (a) the points earned during CCG-play, and (b) the amount of time needed to complete the CCG. Moreover, in order players/learners to be motivated to play more, a high score matrix could be also defined.
- The log files format: Here, the definition of the appropriate information which will be provided by the log files should also be defined.

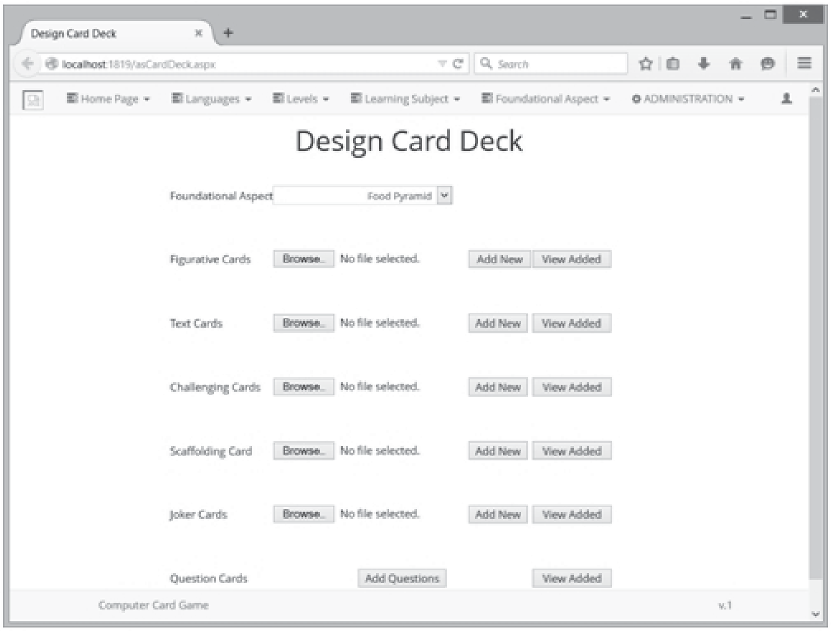

Figure 1: An example of the "Card-Deck Design" screen for the FA-The food pyramid

The aforementioned actions are shown in Figure 2, where the "Main Menu" is presented.

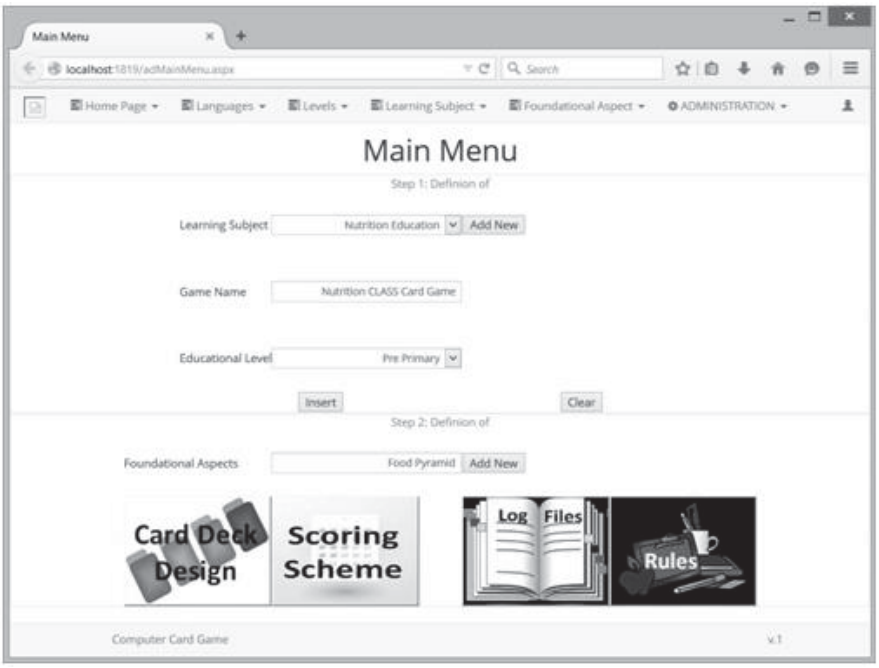

Figure 2: Main menu for the design of Nutrition CLASS CCG

4.2 Play mode

In the beginning of the CLASS CCG play mode, players/learners have to select: (a) the FA they want to play for, and (b) the mode they want to play, namely: *Figure-Cards, Question-Cards* or *Mixed-Cards.* A brief presentation of each mode is described below.

Figure-Cards mode: The related to the selected FA Figurative-cards, Challenging-cards and all Joker-cards alternate in succession and players/learners have to: (a) to select the appropriate Figurative-cards in order to form a valid group of cards for the selected FA, (b) to include the Joker-cards, and (c) to reject the Challenging-cards.

Question-Cards mode: All the related to the selected FA Question-cards alternate sequentially and players/learners have to choose the right answer of each Question-card for the FA in question.

Mixed-Cards mode: This is a combination of the two aforementioned modes, where players have both to form valid groups of cards and also to answer multiple-choice questions simultaneously, all related to the selected FA.

It is worth to mention that for the pre-primary level only Figure-Cards mode is probably appropriate while for the other two educational levels (primary and secondary) all modes could be considered. The initial screen for the Nutrition-CLASS CCG is shown in Figure 3.

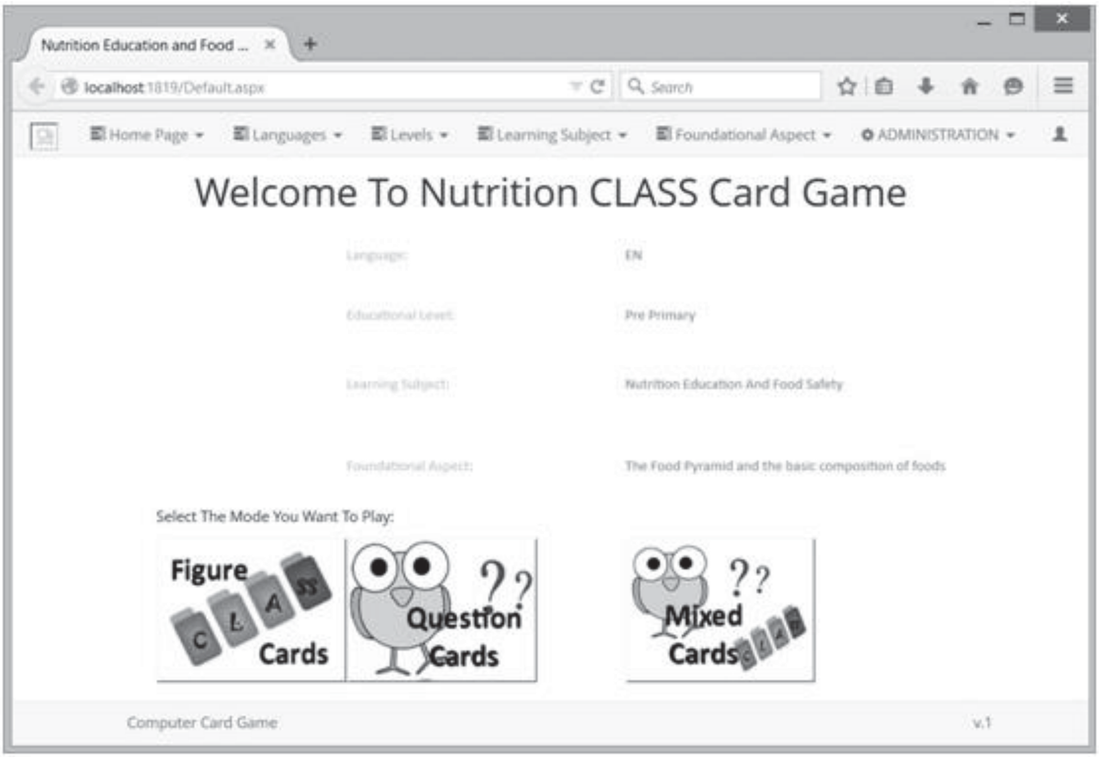

Figure 3: Initial screen of nutrition-CLASS CCG

5. Summary and future plans

This paper presents the design of CLASS, a platform for the development of single-player classification ECCGs (CLASS CCGs) by non computing majors – educators and learners. In fact, CLASS provide them with the opportunity to create their own ECCGs for the learning a subject of a specific discipline, using a simple and user-friendly interface. The design of CLASS CCGs is based on the "7-step modeling methodology" for educational constructivist ECCGs (Kordaki, 2015) where appropriate CCG-play learning activities encompassing: (a) card classification activities, including grouping of appropriate cards and rejection of the non-appropriate ones, and (b) asking/answering appropriate questions where players/learners have to identify the features or attributes of entities of the FA in question, and provide right answers. In order CLASS CCGs to be realized two distinct modes are available for the designers and the players respectively; the design-mode, where designers have to setup the CLASS CCG and the play-mode, where learners have the opportunity of playing it. CLASS platform provides diverse opportunities both for educators and learners. In fact, the CLASS platform could be used by educators for the design of their own CCGs adapted to the curriculum and the learners' needs. Afterwards, during CLASS CCG-play, learners are supported to develop information gathering, remembering, organizing, analyzing, and generating core thinking and critical thinking skills, namely, observation, recognition, knowledge recall, reflection, classification, and identification of relationships among entities as well as analysis of the structural elements of a group.

The evaluation of this platform by educators and learners is in our future plans in order to investigate their attitudes towards it as well as issues concerning its usability. The enhancement of this platform with possibilities for creation of other types of ECCGs, apart from classification-based ECCGs, is also in our future intentions. Such ECCGs could support the development of students' various thinking skills, related to sorting, problem solving, and decision making skills.

All in all, it is hoped that by easing the development of ECCGs by both educators and learners, according to their needs, "CLASS" platform could potentially lower the hurdle for those who strive to create their own educational games but they lack of the appropriate programming knowledge to realize them.

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Zombie Division: A Methodological Case Study for the Evaluation of Game-Based Learning

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Abstract: This paper discusses the methodological designs and technologies used to evaluate an educational videogame in order to support researchers in the design of their own evaluative research in the field of game-based learning. The Zombie Division videogame has been used to empirically evaluate the effectiveness of a more *intrinsically integrated* approach to creating educational games. It was specifically designed to deliver interventions as part of research studies examining differences in learning outcomes and motivation predicted by theoretical contrasts in educational design. The game was used in a series of evaluative studies, which employed experimental methodologies based around one or more treatment groups and a control. Multiple choice questions were used to measure knowledge and understanding before and after interventions (pre, post and delayed) and time-on-task was used as a measure of motivation and preference during interventions. Qualitative interview data was also collected and analysed as part of many of the studies in order to help support and explain the findings in more detail. The experimental methodologies applied in these studies were augmented by a range of bespoke technology systems. This included an automated testing system which could randomly assign participants to treatment groups so that pre-test statistics were closely matched between groups. Large quantities of process data were recorded about players' interactions with the game in the form of time-stamped log files, and a stream of compressed controller data was saved allowing an entire playing session to be replayed in a video-like form. This rich set of process data was mined as part of a post-hoc analysis in order to identify evidence to help to enrich the understanding of users' interactions with the game. This paper details the methodological design of both published and unpublished studies, as well as reflecting upon some of the potential pitfalls of classroom-based evaluations in order to illustrate successful and unsuccessful approaches for evaluating game-based learning.

Keywords: game-based learning, evaluation, experimental design, learning outcomes, motivation

1. Introduction

Academic research into digital game-based learning now spans five decades (e.g. Cullingford, Mawdesley et al. 1979), yet relatively little has been established in terms of a common methodological practice for empirical research in this field (All, Castellar et al. 2014). Perhaps this should be expected given the inter-disciplinary nature of this area of study, which brings together computing, education and psychology, with any other discipline that seeks to apply game-based learning to its own teaching. It is natural for researchers to carry the epistemological assumptions of their own disciplines and seek to ask research questions which lend themselves to different methodological approaches. Nonetheless, the credibility of the field is hampered by its failure to produce a substantial body of empirical research demonstrating the effectiveness of game-based learning (Blunt 2007, O'Neil, Wainess et al. 2005, Abdul Jabbar, Felicia 2015). In order to facilitate more evaluative research within this field, this paper provides a practical insight into a research project which was able to empirically demonstrate an impact on motivation and learning.

Zombie Division is a third-person perspective videogame adventure which teaches mathematics to seven and eight year olds (figure 1). It was designed to examine the effectiveness of game-based learning in which the learning content is very tightly coupled with the gameplay (Habgood, Ainsworth et al. 2005). This approach was based on the observation that poor game-based learning often has a very loose coupling between learning and gameplay, allowing it to be characterised as "chocolate-covered broccoli" (Bruckman 1999). The term "intrinsic integration" was used to describe this tight coupling in keeping with earlier literature (Kafai 2001, Malone 1981) contrasting it with the "extrinsic integration" exhibited by typical 'edutainment' products (Papert 1998).

2. Effective game-based learning

Any research design attempting to evaluate the effectiveness of game-based learning must first decide what it means to be effective. The Zombie Division research adopted a quantitative, quasi-experimental approach to evaluating effectiveness based on pre to post-test gains (as a measure of learning) and time-on-task (as a measure of motivation). In addition, a range of qualitative interview data was collected in order to enrich the interpretation of the experimental results. The combination of educational and motivational measures of effectiveness have intuitive face value for demonstrating the potential of game-based learning, but neither is without its complications.

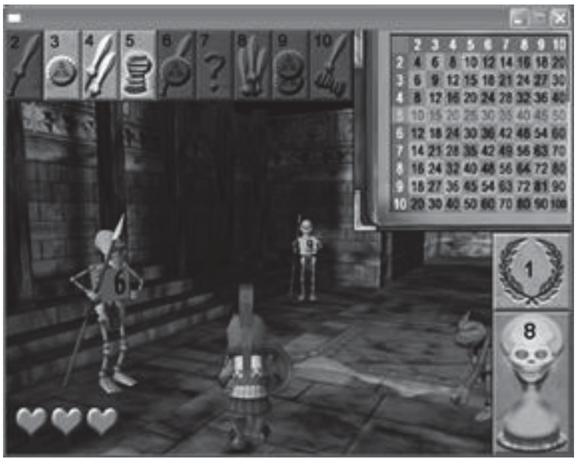

Figure 1: The intrinsic version of Zombie Division

2.1 Educationally effective

Learning gains are a common measure of effectiveness (O'Neil, Wainess et al. 2005, All, Castellar et al. 2014), but demonstrating knowledge acquisition doesn't necessarily make a mode of learning effective—crawling hardly qualifies as an effective mode of travel, despite the ability to demonstrate progression! The concept of "effectiveness" naturally incorporates the idea of being (at least) comparable to the status quo, but finding the right comparison raises additional epistemological and methodological challenges.

There is often a desire to compare game-based learning to traditional modes of teaching (e.g. Randel, Morris et al. 1992), and frame research questions in terms of whether game-based learning is instructionally more effective than classroom teaching. However, the Zombie Division research was designed from the perspective that this kind of question realistically cannot be addressed in a typical, small to medium scale research study. The strong influence of an individual teacher's performance during a short intervention (often at the end of a teaching year) presents a significant threat to the external validity of any results. The approach adopted within this research has tried to keep the teacher's role as a common factor in any intervention, preferring to explore how classroom teaching can be augmented by game-based learning rather than replaced by it.

The Zombie Division studies were primarily concerned with the comparison between two different approaches to game-based learning: the loosely-coupled (extrinsic) approach offered by edutainment products (i.e. the status quo) and the tightly-coupled (intrinsic) alternative proposed by our research. The studies focussing on learning gains incorporated an additional control group condition which offered a baseline comparison with no learning (but identical gameplay). In this way it was possible to explore whether an extrinsic approach could produce any learning gains and whether the intrinsic approach was more or less effective than it.

2.2 Motivationally effective

Learning gains are not the only potential measure of an educational game's effectiveness, and historically it is the motivational potential of game-based learning that has been the driving force for much of the interest into the field (e.g. Bowman 1982). The link between motivation, time-on-task and learning is supported by research outside of games (Vollmeyer, Rheinberg 2000) and time-on-task is an objective measure of motivation which has a long tradition of use in motivation research (e.g. Deci 1971). Self-reported measures of motivation can have a range of shortcomings (Fulmer, Frijters 2009), and lack the objectivity required to demonstrate efficacy in the same way. Consequently the Zombie Division studies recorded time-on-task as the principal measure of motivation and didn't pursue self-reported measures beyond collecting interview data to add depth to statistical findings.

Finding a meaningful comparison for motivation is equally problematic, but here the implicit comparison is not with the classroom, but the home. The 'utopian dream' of game-based learning research would be an educational game which could effectively compete for attention against blockbuster console games. However, it is unlikely that even the most commercially successful 'brain-training' franchises would perform very favourably in a direct comparison of this kind. In the home context researchers may have to consider an effective educational game as one which can compete for a slice of children's time amongst the complex picture of media consumption with in the home (Ofcom 2014). Classroom-based research allows the range of competing activities to be more carefully controlled, but it is not without its own complications.

3. Classroom research

The practical and ethical realities of undertaking research within a school setting has a significant influence on methodological design. Subject specialisation in secondary/high-school teaching makes research harder to accommodate within the school timetable, and the 7-11 age group is often preferred for the relative autonomy that school teachers have over the daily routine. Even so, any research programme carried out in schools will typically need the backing of both class teachers and the head of the institution in order to proceed. Our own experience running videogame related activities with schools (both research and outreach through the Games Britannia festival) is that videogames can still have strong negative associations amongst some staff, and consequently not all schools will engage with this kind of activity. It is particularly important therefore that game-based learning researchers are mindful of the responsibilities of using games for research.

3.1 Ethical considerations

Classroom research has significant advantages in terms of participation, but careful consideration must be given to how long it is ethical to remove children from their normal studies. Any study which incorporates a control group is potentially putting one group of children at an educational disadvantage to their colleagues. Consultation with teachers in this research programme, concluded that around twenty minutes per day for seven days was an appropriate amount of time away from lessons. This may seem like a relatively low figure, and examples of much more time-consuming educational research does exist (e.g. Kafai 1996), but the limit takes into account the additional time (and disruption) involved in taking three separate groups of children out of their normal lessons and getting them to and from the school's IT suite. To compensate for the lack of educational content in the control group's intervention, these children were optionally offered the opportunity to play the intrinsic version of the game during their lunch hour in the weeks following the end of studies.

Age-ratings present another ethical issue which is specific to researchers using videogames. Most territories now have their own legal rating systems which determine what is considered appropriate content for games classified under different age categories. The PEGI rating system is used across most of Europe and it has been illegal for retailers to sell games to underage children in the UK since 2012 (Sweeny 2012). The formal age-rating process is only applicable to published products and not closed research prototypes, but details of the requirements are freely available and should be followed by researchers. The Zombie Division prototype was designed according to the PEGI rating for a 7+ game with "depictions of non-realistic violence towards fantasy characters", being the maximum level of violent content experienced in the game.

3.2 Participants and group sizes

Twenty participants is often considered the minimum group size for statistical reliability in quasi-experimental studies of this kind. That means that designs involving three treatment groups require more than sixty participants to accommodate some level of dropout. A typical primary school in the UK has two classes per year group, and most conform to a target class size of less than thirty pupils, making it impossible to run a three group classroom study without involving two cohorts of pupils. In the first classroom study (design 1) two complete year groups of 7-8 and 8-9 year olds were enlisted totalling sixty-four pupils. Fifty-eight pupils took part in the second classroom study (design 4), comprising of an entire 7-8 year group topped up with students picked by their class teacher from the year below. The class teacher's selection was based on combination of age, maturity and mathematical ability, and in mind of an ethical consideration for selecting students who would not suffer from being removed from their normal teaching.

The two studies examining motivation were both conducted outside of normal school hours and used fewer than three treatment groups. The first of these took place during the school holidays (design 2) and recruited forty-four, 7-8 year olds from different schools into just two treatment groups (no control). The second was run as an after school club (design 3) with just a single group of sixteen pupils. Throughout all four studies parental permission was always sought to take part in the studies, and notably never refused.

3.3 Matched, randomised assignment

Randomly assigning participants to treatment groups helps to avoid unintended differences between groups influencing the outcome of the intervention (confounding factors). However, differences between groups can still arise through random chance when the number of participants in each group is small (as they typically are in educational studies). Matched designs can help to avoid this by sorting participants based on a matching variable (often pre-test scores) and then randomly assigning similarly scoring participants between the treatment groups. Groups can be balanced for binary attributes such as gender at the same time by simply performing the same process separately for males and females. This process will generally ensure that the mean scores for each group are comparable and any difference observed at the end of the intervention can be more reliably attributed to the independent variable rather than any difference between treatment groups.

Matching participants based on a single pre-test variable is relatively easy to perform by hand, but usually requires a separation in time between the pre-test and main intervention (to perform the grouping). Unfortunately this separation often means that carefully matched pre-test scores will be distorted by an inevitable level of absenteeism at the actual intervention. Although the matching process still helps to minimise any potential distortion, lost participants can alter mean pre-test scores by a disappointing margin over the course of a longer study. Such differences can end up disguising any potential outcome of the study as ANOVA-based statistical analyses use the group variance to determine whether an outcome is statistically significant.

4. Designing a game for research

This paper is primarily concerned with discussing the methodological approaches which were successfully and unsuccessfully applied to the evaluation of Zombie Division. Both the design of the game and the main outcomes of the studies are described in detail elsewhere (Habgood, Ainsworth 2011, Habgood 2007) and it is beyond the scope of this paper to revisit those aspects of the work. Nonetheless, a brief summary is provided here to facilitate the ongoing discussion of methodological design.

The biggest single influence on the methodological design of the Zombie Division studies was the limited amount of time which participants would have to play the game. Observing learning gains in just two hours of play is a significant challenge given the time required to become familiar with controls, avatars and objectives in any game. Nonetheless the concept was designed with this time constraint in mind and so a number of practical design decisions were made in order to try and facilitate its success as a research tool:

- The game and its control mechanisms were designed to mirror those of typical third-person action-adventure games familiar to children of the target age group (e.g. Spyro, Harry Potter, Zelda). Only the combat controls were unconventional as these required players to use the function keys to perform a corresponding division operation (e.g. F2 divided by two, F10 divided by ten).
- The educational content of the game was focussed on teaching a single mathematical concept (the inverse relationship between multiplication and division) and the game provided a mathematical representation which implicitly provided the correct division operations once this concept was understood. Thus a single mathematical 'epiphany' could potentially lead to a huge improvement in performance. The national curriculum at the time determined that the inverse relationship would be a relatively new concept for the year groups targeted by these studies.

In this way the intrinsic version of the game had a tight coupling between the gameplay and learning content where mathematical division was fundamental to the game's combat mechanic. The extrinsic version was exactly the same game but with the mathematical relationship removed from the combat mechanic. It then included identical mathematical content in the form of multiple choice questions at the end of each level (see figure 2). Both the intrinsic and extrinsic groups had access to the mathematical representation during the appropriate aspects of their respective games. The control version was the same as the extrinsic version without the multiple choice questions (i.e. no mathematical content at all).

5. Design 1: Learning gains

The design of the first study compared learning gains over five sessions, each lasting twenty minutes (once a day for a single week). Paper-based pre-tests were delivered on the Friday before the intervention week and used to perform a matched assignment of participants to each of the three conditions (intrinsic, extrinsic and control). For each session, children played the game together within their treatment groups inside the school's ICT suite.

The children wore headphones and the game contained audio prompts which explained how to play the game without the need for additional direction by teachers or researchers. No classroom instruction was delivered relating to the game's content, and the teachers avoided covering the relevant mathematical concepts in class for the period of the intervention.

Figure 2: The extrinsic version of Zombie Division

Statistical analysis of the results showed that learning had taken place, but there was no demonstrable difference in the learning between the three different conditions. The results looked as might be expected (improvements in the intrinsic and extrinsic conditions and almost no difference in the control), but large standard deviations meant that none of these differences were statistically significant. It was also noticeable that pre-test scores which were initially matched, had drifted upwards in the intrinsic and extrinsic groups as a result of absences, making it even more unlikely to detect any differences between mean group scores.

This first evaluation attempted a very clean approach to the (quasi) experimental design by trying to control for any influence that teachers or researchers might have on the intervention. While methodologically desirable, later designs would acknowledge the important role that teachers play in providing the link between game-based learning and children's wider understanding (Sandford, Williamson 2005). At this stage the game contained relatively little support for scaffolding children's understanding of the mathematical concepts involved, and for some children it was clear that applying the chosen mathematical representation (a number square) to division tasks was well outside of their "zone of proximal development". The children's class teachers recommended using a multiplication grid as a more familiar representation they might readily associate with multiplication and division and so this was adopted in subsequent studies (see figure 2).

Further investigation of the pre-test results showed that the testing instrument had introduced a significant flaw in the design of the study. Despite trialling the test in advance on children the same age, it was too easy for the children who took part in the actual study, as one quarter of them achieved a score of over 70% in the pre-test. This creates a "ceiling-effect" in which the higher scoring children have less scope to demonstrate improvement as a result of the intervention. This was supported by the statistical analysis which showed that the improvement between pre and post-test was only observable in the most difficult questions.

6. Design 2: Time-on-task vs. alternative

The design of the second study compared time-on-task over three sessions lasting forty-five minutes during a single day. A computer-based pre-test was delivered at the start of the study and used to perform a matched assignment of participants to the two conditions (intrinsic and extrinsic). For the first forty-five minutes of the study, participants were asked to play their assigned versions of Zombie Division with no alternative activity provided. Following a short break, they were given access to a "home screen" which allowed them to switch freely between playing their assigned version of Zombie Division and a range of non-educational games from the BBC website. This continued for the two remaining forty-five minute sessions, with a short break in-between.

Analysis of the results showed that there was no statistical difference between the amounts of time spent playing the two different versions of the game. However, boys across both groups did play Zombie Division for longer than girls (74% of their optional playing time compared to 51%).

Undertaking an entire intervention in a single day avoids the problem of absentees, but requires grouping to take place almost instantaneously. Even though this study was primarily concerned with motivation it is likely that mathematical ability could have a direct effect on children's motivation to play a mathematical game, so matched grouping based on pre-test score was still desirable. The ceiling-effects observed in the first study had already prompted the implementation of a computer-based testing system which could deliver a (practically) endless number of questions in a fixed amount of time in order to prevent this problem re-occurring. For this study a client-server system was added in which each participant's data was sent back to a server program to be matched. Once all the pre-tests were received, the groups were assigned and broadcast back to the client machines so that participants could immediately begin playing the correct version of the game.

While the system itself worked flawlessly during the study, it proved to be methodologically problematic as it introduced contamination between groups. Many participants sitting adjacent to each other found themselves assigned to different treatment groups, and it became clear that individuals in different conditions were directly competing to see who could progress the furthest. This competition was a particular issue for the way this study was examining motivation and the system was not used again. Nonetheless it could be effective in a situation in which it was possible to relocate the students between the pre-test and intervention.

7. Design 3: Time-on-task with free switching

The design of the third study compared time-on-task over three weekly sessions lasting forty-five minutes each as part of an after-school computer club. Throughout the study participants had access to a "home-screen" which allowed them to freely switch between the intrinsic and extrinsic versions of the game without suffering any overall loss of progress. The order of the selection buttons was randomised each time they returned to the home screen. Participants were initially shown the two versions of the game running side-by-side and asked to make sure that they tried playing both versions during the club. They were also free to choose to do their usual club activities instead (just about any activity available on the school PCs). In a fourth club session the pupils were interviewed about their experiences and asked to describe the differences between the two versions.

Statistical analysis of the results showed a huge preference for the intrinsic version of the game, which children played for over seven times longer than the extrinsic version.

The direct comparison between the two versions of the game demonstrated that children had a clear preference for the intrinsic version of the game, but the interview data showed a more complicated set of motivations behind this choice. Competition within the group was clearly a strong motivating factor and some children felt that it was quicker to progress through levels in the intrinsic version of the game (as the quiz took additional time). Nonetheless it was clear from some of the other comments that they possessed a surprisingly deep understanding of the design choices used in the two versions and one even astutely described the intrinsic version of the game as "like subliminal learning with maths" (Habgood, Ainsworth 2011, p.195).

8. Design 4: Learning gains with teacher-led reflection

The design of the final study is meticulously documented elsewhere (Habgood, Ainsworth 2011), but mirrored that of the first study with the addition of teacher-led reflection activities half-way through the intervention week. This consisted of a thirty five-minute session away from the game in which a classroom teacher delivered mathematical reflection activities on division. For each group the content was tailored to the context of their gaming experience, but contained identical learning content (including the numerical examples). For the control group the same learning content was delivered without reference to the game. The final difference was the inclusion of another short playing session two weeks later followed by a delayed post-test.

Statistical analysis of the results showed that children in all conditions demonstrated learning gains (as would be expected given the inclusion of the teacher-led reflection), but children who played the intrinsic game scored significantly higher than children in either of the other two groups.

The methodological design of the final study was a culmination of the hard-won experience of the entire programme of research. As well as including the teacher-led reflection, additional instructional scaffolding had been added to the game itself (mirrored in both the intrinsic and extrinsic versions). This was trialled in the earlier motivational studies to ensure that it was functioning correctly and appeared to benefit children's understanding of the mathematical concepts involved. The problems with ceiling effects observed in the first study were solved by the computer-based test and provided an additional set of process data which could be compared with that already produced by the game.

9. Process data

Zombie Division contained two separate systems for generating detailed process data from the player's interactions with the game. The first created a time-stamped log file recording key game events such as entering a room, attacking a skeleton or collecting a key. These log files were mined in a post-hoc analysis for additional information about the player's learning and behaviour (Baker, Habgood et al. 2007). This process of data-mining is comparable to attempts to record and analyse 'game analytics' in commercial games (Sifa, Drachen et al. 2013). For example it was possible to use this data to observe a strategy in which children ran into a room containing skeletons, quickly ran out again, and waited before running back in again to attack. This suggested that they were deliberately creating time and space to work out the answers from a safe position. In fact this behaviour was replaced over time as pupils realised that pausing the game had the same effect. The increase in players' use of this pausing behaviour (and the difference with the extrinsic group) can be seen in figure 3.

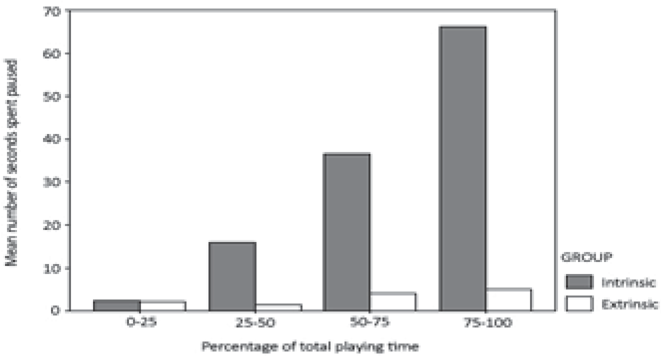

Figure 3: Time spent in the pause menu over the course of the intervention

9.1 Input streaming

The videogaming industry has long used the deterministic properties of games to record and replay in-game action using controller input streams. This relies on the principle that code should produce identical output each time it receives the same input. Even random number generation is deterministic and will produce the same output starting from the same "seed". This makes it possible to record a stream of input data (information about which keys are pressed for every frame of the game) and use it to replay the game in a video-like form at a later point in time. However, it takes just a tiny fraction of the storage required by a video and will compress very effectively using a simple run-length-encoded (RLE) algorithm. In the case of Zombie Division this means that the 130 hours of playing time from the final study takes up less than 8 MB of storage! The principal danger with this method of recording is that it is reliant on keeping the exact same version of the game used to record the data and the smallest change in the game itself results in wholly inaccurate replays.

10. Conclusion

Game-based learning is not as young a field as many might believe, but it has yet to produce a substantial body of empirical evidence which establishes the potential of learning games as effective educational tools. Researchers have approached this field from a diverse range of research interests and with a broad range of methodological approaches—all of which contribute to the depth and richness of understanding necessary to explain such complex artefacts. Nonetheless, the advancement of the field requires more empirical studies which are designed to collect evidence which directly supports or rejects the fundamental assumption that game-based learning can make an effective contribution to education.

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The School at Play: Repositioning Students Through the Educational use of Digital Games and Game Dynamics

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Abstract: The aim of this paper is to present findings from a pilot study that relates to an on-going research project on the use of digital games and game-based pedagogies for supporting children in learning difficulties. The research project is entitled "The School at Play: Learning and Inclusion through Games and Game Dynamics" (2015-2017) and has been funded by the Egmont Foundation to be implemented in eight math and Danish classes (grades 3-6) distributed across four different Danish schools. The methods involve the use of digital games for creating meaningful contexts for learning and a number of visual tools and pedagogical approaches for clarifying and reflecting on students' progression in relation to social, curricular and game-related aims. Based on the theoretical framework of scenario-based education (Hanghøj *et al.*, 2014), the findings from the pilot study shows how a teacher and a student position themselves in relation to the shifting frames of the game-based teaching method. The preliminary findings suggest a number of possibilities and challenges involved in using the method for providing students with new learning opportunities, which emphasizes the important role of the teacher in adapting and facilitating the method.

Keywords: game-based teaching, games and inclusion, teacher roles, scenario-based education, framing, positioning

1. Introduction

Schools in modern society face a major challenge in terms of including students, which are positioned as having or being in various types of learning difficulties. In the public debate, the challenge of inclusion is often related to teachers and students' experience of "noise" in the classroom (Larsen & Dyssegaard, 2013; Nordahl & Sørlie, 1997; Ogden, 1998). However, the term "noise" is quite problematic as it reduces students' troublesome behaviour to symptoms, which tell little about the cause of the behaviour or how particular students position themselves and become positioned as "noisy", and what pedagogical methods that can be applied in order to address the "noise problem" – e.g. by focusing on students' lack of motivation or interest in taking part in the learning activities in the classroom.

Parallel to the growing public perception of students with troublesome behaviour as a major educational challenge, the last 10 years have seen an increasing interest both among researchers (Gee, 2003; Stewart *et al.*, 2013) and teachers (FutureLab, 2009; European Schoolnet, 2009; Takeuchi & Vaala, 2014) in the use of digital games and game dynamics in the classroom. This interest is often driven by the assumption that game-based learning environments may provide students with more engaging and meaningful ways of participating in formal education. Arguing along similar lines, the focus of this paper is to describe how the use of particular game-based pedagogical approach entitled "the School at Play method" may be used to offer students new forms of participation in the classroom and reposition their identity as learners. More specifically, the empirical focus for the paper involves a pilot study of the School at Play method in relation to a Danish curriculum designed for the digital game *Torchlight 2*, which is a commercial action role-playing game (ARPG), where players collaboratively explore dungeons and fight monsters in order to gain experience and loot. The study was carried out by observing a teacher and her students in a 3rd grade in the subject Danish during the fall of 2014. Due to the limited scope of the collected data, the aim is not to make overall claims on the effectiveness of the School at Play method, but mainly to present a theoretical framework, which can be used to analyse and understand how the game dynamics of the method may frame students' patterns of interaction and how it tries to reposition them as active participants in a formal school context. This leads to the following research question: How can the School at Play method be used to frame game-related learning activities in order to reposition and include students through meaningful participation in the classroom?

2. Relevant research

The research on games, learning and inclusion has mostly focused on the use of learning games or so-called "serious games", which are often of low quality (Stewart et al., 2013). The relatively few studies using commercial games for inclusion indicate positive results. As an example, one successful study involved the design of a two year experimental curriculum in a Swedish municipality mainly based around the use of World of Warcraft, which targeted boys in risk of dropping out of upper secondary school (Wiklund & Ekenberg, 2009).

Moreover, there also exist research, which documents the valuable pedagogical use of analogue game dynamics such as the consistent use of role-playing activities, narratives and quests at a Danish boarding school (Gjedde, 2014). Regardless of the particular games and game dynamics being used, there is increasing evidence and acknowledgement that the role of the teacher and choice of pedagogical approaches is crucial when it comes to facilitating game-based learning (Hanghøj, 2013; Hanghøj & Hautopp, 2015). In this way, there is a significant need for more detailed research on how the pedagogical use of specific games and game dynamics may be used to include marginalised students as meaningful participants in the classroom.

3. The School at Play method

The School at Play method can be described as a combined pedagogical use of commercial games and game dynamics in order to achieve both curricular and social aims within a classroom context. The method has been developed by a teacher, Stine Melgaard Lassen, and a social educator, Tore Neergaard Kjellow, who has worked over the course of 3 years as colleagues in special education before starting a consulting firm that specializes in game-based learning (www.skolenispil.dk).

One of the key principles of the method is the design of game-oriented curricula, which involve the use of commercial digital games for creating meaningful contexts for collaboration, discussion and learning. This means that students are given the opportunity to play and explore particular game worlds (e.g. the co-op action role-playing game *Torchlight 2)* in order to understand specific game mechanics and tactics. Moreover, the students are also asked to analyse, understand and reflect what kinds of disciplinary knowledge within math or Danish that may be relevant to learn in order to get advantages when playing the game. In this way, a core aim of the method is to establish a dual interplay between, on the one hand, learning to play specific games and understand how their game mechanics relate to disciplinary knowledge in e.g. the subjects Danish and math, and, on the other hand, learning how to use different types of disciplinary knowledge in order to improve game play. In this way, the method share resemblances with the integrated use of game-based learning and systems thinking as it is practiced at the Quest2Learn school in New York (Salen *et al.*, 2010) and embedded in the educational online game design tool *GameStar Mechanic* (Salen *et al.*, 2014).

In addition to using digital games as a meaningful context for learning, the method also offers a number of analogue visual tools that facilitate game dynamics in the classroom such as a the "Progress Bar", "Portal Assignments", and the "Token Tracker". The Portal Assignments asks students to explicitly link disciplinary knowledge to in-game tasks. An example that links *Torchlight II* and math: "A Health Potion gives 900 health over the duration of 8 seconds. A Big Health Potion gives 1.800 for the same duration. How much health per second do you get from 1 Health Potion?" Every time students solves assignments, which may both involve game-related Portal Assignments and non-game related assignments, the students are able to move their name on the Progress Bar, which is located on a wall in the classroom. The Progression Bar ranges from 0 to 100% completion with the additional option of progressing up to 150%. Beforehand, the students have been divided into three different levels of expertise by the teacher, which means that even low-performing students are given fairly easy possibilities for fast progression. In contrast to the other two tools, which link activities and curricular aims, the primary aim of the Token Tracker is to regulate students' behaviour in the classroom. Based on "Class Virtues" such as arriving in class "On time" or showing "Respect" by not making unnecessary noise, which have been identified by the teacher in dialogue with the students, the teacher may award tokens to students, who practice the virtues listed on the board. Once given, students cannot lose their tokens. From time to time, the virtual economy of the tokens may be traded to real-life resources, which means that students may be allowed to leave class a bit earlier or spend extra time playing the digital game.

Finally, it is worth noting that the School at Play method is more than a "technical" pedagogical system as it goes beyond merely integrating digital and analogue game dynamics. The method is based on pedagogical values and approaches, which are highly important when facilitating the method. One of the most important values is to explicitly acknowledge students' achievements, which may be in-game and/or in-class as well as related to disciplinary knowledge and/or only behavioural aspects. In this way, the teacher plays a crucial role not only in planning and staging the method, but also in facilitating dialogue and providing relevant forms of feedback to the students during their progression and behaviours in a game-oriented learning ecology.

4. Theoretical perspectives

Theoretically, the paper draws on two perspectives: educational gaming as a form of scenario-based education and the complementary concepts of positioning and framing.

4.1 Scenarios and domains

Based on the author's earlier work, the educational use of games and game dynamics can be understood as a form of scenario-based education (Hanghøj, 2011a, 2013; Hanghøj *et al*., 2014). This means that games represent interactive scenarios, which participants can explore by imagining, enacting and reflecting on different choices that involve "various competing possible lines of action" (Dewey, 1922: 132). Moreover, it is assumed that the process of facilitating and playing game scenarios in educational contexts involves translation of knowledge practices across four different domains: the domain of schooling, the domain of disciplinary knowledge, the domain of everyday life, and the scenario-based domain of particular games (Hanghøj *et al*., 2014).

By using the framework of scenario-based education it becomes possible to understand how the *Torchlight 2* curriculum, which created the context for the pilot study, involved knowledge practices from all the four domains. More specifically, the domain of schooling refers to the institutionalised pedagogical practices recognised as school only, e.g. practices deriving from the special asymmetric relationship between teacher and student. This involves the teachers' everyday practices for giving overt instruction or guiding students as well as the students' everyday work forms such as doing group work or solving individual assignments. The disciplinary domain refers to the subject-specific discipline of Danish, which implies specific disciplinary topics and concepts such as the analysis of genres and narrative structures. Third, the scenario-based domain refers to the in-game world of *Torchlight 2* and game specific practices such as exploration, combat, collaboration or trading. Finally, the everyday domain refers to non-specialised knowledge practices that mainly exist outside school contexts, such as the students' everyday knowledge and experience with digital games. The dynamic relationship between the four domains is illustrated below (fig. 1) as a series of translations between different knowledge practices.

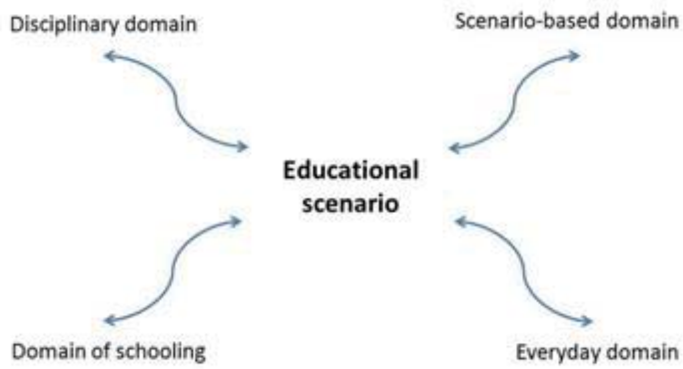

Figure 1: The translation of knowledge practices across domains

In order to understand how teachers and students experience and create translations of knowledge practices across the four domains, I will now introduce the two complementary analytical perspectives of framing and positioning.

4.2 Framing and positioning

The first analytical perspective concerns the *framing* of learning contexts, which refers to social actors' shared principles for organising their experience of "what is going here" (Goffman, 1974; Fine, 1983). As an example, a particular game-related learning activity may involve quite different experiences for the participating students, which relate to different domains – e.g. students being instructed by the teacher to form groups (pedagogical domain), students reading an assignment (disciplinary domain), students checking their phones for text messages (everyday domain) and students trying to progress within the game being played (scenario-based domain). Depending on the on-going negotiation between the social actors of a learning context, the framing of particular situations may involve foregrounding and backgrounding of different types of domain-specific knowledge practices, which may sometimes create meaningful translations and other times result in frame "clashes" between different expectations (Hanghøj, 2011). In this way, the notion of framing may be used to analyse situated aspects of how the knowledge practices of specific game-related learning activities are experienced by the social actors of the classroom.

The second analytical perspective draws on the work of Dialogical Self Theory (Hermanns, 2001; Ligorio, 2010), which argues that human beings continually take up different *I-positions* as they communicate and interact with others. This means that teachers and students may position themselves and be positioned quite differently in different situations. Seen in relation to the domain model presented above, it may be argued that playing a digital game at home (everyday domain) offers a different range of I-positions than playing the same game at school (domain of schooling).

In this way, game-related learning contexts may offer students the opportunity to enlarge and reorganise their repertoire of I-positions. Similarly, teachers may experience wholly different I-positions when teaching with games in contrast to their everyday identities as "authorities" in the classroom.

Taken together, the two concepts of positioning and framing may be seen as complementary analytical concepts as they can be used to describe different, but equally important, translations across domains and knowledge practices when facilitating and participating in educational game scenarios.

5. Methodological approach

The pilot study described here is intended to inform a larger research project entitled "The School at Play: Learning and Inclusion through Games and Game Dynamics" (2015-2017) funded by the Egmont Foundation. The research project follows the methodological approach of Design-Based Research (Barab & Squire, 2004), which means that the pilot study represents the starting point for a continuing series of design interventions that aims to generate local theories and refine the School at Play method through several iterations between curricular design, use, analysis, and redesign. In this way, the findings of this pilot study presented here will inform future research and interventions with the School at Play method in the larger research project.

The curriculum design for the pilot study involved the use of the co-op action role-playing game *Torchlight 2*. In order to promote collaboration between the players, the game is played at the highest level of difficulty. This means that without close collaboration, the players are unable to progress significantly within the game. Moreover, the *Torchlight 2* curriculum required that teachers identified local curricular aims in both Danish and math (between grades 3 to 6) to be pursued over a period of three weeks. The curriculum had been developed as an offer to interested teachers at different schools in a Danish municipality, which had hired the two consultants behind the School at Play method to develop in-service teachers' competencies. For practical reasons, I was only able to observe one Danish teacher using the *Torchlight 2* curriculum for a few days, which explains the limited scope of the pilot study described here.

The teacher was a first-time user of the method and only had limited experience with using digital games and game dynamics in the classroom. In order to observe how the game-based teaching method might reposition students in learning difficulties, I decided only to focus on a few students. Based on an interview with the teacher before the observations, a student which we will here call Peter was identified as one of the students in class to be observed. More specifically, the teacher described Peter as a student, who often had difficulties with concentrating in class, especially in relation to assignments, which he could not solve right away. The data collection was based on four days of observations with the School at Play method, which followed the two consultants and the Danish teacher using the method in the same 3rd grade Danish class. The observations involved video recordings of classroom interaction as well as field notes. A post interview was conducted with the teacher. I also tried to interview Peter, but he was not interested in being interviewed during my brief visits at the school. The data was transcribed and coded with an emphasis on significant events, which could be used to describe how the School at Play method could frame and reposition students. In this way, the analysis does not focus mainly on individual teachers and students, but rather on the meaning-making *relations* between the participants in the educational scenario (Gee & Green, 1998).

6. Analysis

The analysis focuses on the positions of the student Peter in relation to the School at Play method and how it was facilitated by the two consultants as well as the teacher during the *Torchlight 2* curriculum.

6.1 Learning from games

The *Torchlight 2* curriculum started out with a guided discussion lead by the two School at Play consultants Tore and Stine, who asked the students to describe what they experience having learned from playing commercial games out of school. During the discussion, several students mentioned that they have learned "English" and "collaboration" from playing computer games. Peter was quite excited about the discussion and eager to contribute, but his answers were explicitly ignored by Tore as Peter was unable to sit quiet on his rotating chair and blurted out answers without raising his hand. After several minutes of failed attempts to take part in the classroom dialogue, Peter managed to follow the rules for classroom dialogue and was allowed to describe how he had "become better at writing English" from playing *League of Legends*. By eventually following the shared ground rules implied in the framing of the classroom dialogue, Peter was able to contribute meaningfully to the discussion and position himself as a *learner* in relation to playing games.

6.2 Playing "The School Game"

As mentioned, it was difficult for Peter to concentrate and he often ended up rotating on his chair, being distracted by other students or forgetting to raise his hand when he wanted to say something in class. During the introduction to the Token Tracker system, which was explicitly framed as a "school game", Tore and Stine frequently awarded tokens to Peter and other students when they managed to avoid troublesome behaviour for longer periods of time and follow the norms for "Respect" in the classroom. Whenever Peter was given tokens he was also praised – e.g. through comments such as "you have quite simply become really good at sitting quietly with your hand raised!" In this way, the tokens were not just handed out in mechanical praise of Peter's behaviour. Instead, the two consultants made sure to communicate the reasons for giving each of the tokens and each time describe what had been accomplished. Peter showed clear signs of appreciation of the tokens, e.g. by lifting both hands over his head in excitement, which indicated that he wished to position himself as a competent player of "the school game". However, it may also be argued that the tokens could be experienced as punishments (e.g. by not getting one) or might have the unintended consequence of positioning students as individualised learners in contrast with the aim of promoting their mutual collaboration.

6.3 Exploration and cooperation in Torchlight 2

The students' in-game activities when playing *Torchlight 2* was initially framed as an open-ended exploration of the game with no specific curricular aims. The students played together in teams of four and were quite engaged when discovering the game world, sharing knowledge on the game mechanics and coordinating their efforts to survive swarms of attacking monsters. This behaviour also characterised Peter, who shifted between conducting individual raids and helping team mates, who were not as familiar as him with the game genre. Lisa, who was sitting next to Peter, regularly asked him about in-game actions – e.g. whether the game characters were controlled by using the keyboard or the mouse. Sometimes Lisa was cut off by Peter with a "No!", but he often showed her what to do and helped her to progress in the game. This behaviour was both observed by the teacher and the two consultants, who praised him "for helping others on his own". In this way, the game allowed Peter to become positioned both as a game expert and as a valuable support to his classmates. At the same time, the teacher clearly also felt challenged due to her lack of experience with *Torchlight 2*, especially when asked by students, who came to her in order to get help on how to progress within the game.

6.4 Linking game experience to disciplinary knowledge

The final example concerns the teacher's attempt to link the students' in-game experience of *Torchlight 2* to the disciplinary domain of the subject Danish. The teacher had planned to compare the students' analysis of their in-game characters with the reading of the children's book *I am Frede* [*Jeg er Frede*], which revolve around the theme of being a hero. In this way, the hero theme should create a bridge between analysing the characters in the game and in the novel. However, this attempt to thematically integrate the framing of the two genres was clearly not successful. Whenever the teacher asked the students questions about their characters in *Torchlight 2*, she received numerous elaborated responses. However, when she moved on to talk about the novel, fewer students wanted to participate in the discussion. The majority of the students' lack of interest in the novel created a lot of disruption and troublesome behaviour in the class and the teacher frequently asks the students to be quiet. Most of the teachers' questions about the book were answered by the same small group of students, which did not include Peter. But when the teacher returned to ask questions about the narration in digital games, Peter raised his hand again in order to participate and described how the story in *Legend of Legends* was told through other players, "who tells you where to go".

Later on, the students were given "solo quests" (individual assignments) that related to the novel, which Peter was unable or uninterested in solving. During a break, Lisa came up to him and sat next to him in order to help him with the assignment, somewhat similar to when he had helped her learning to play *Torchlight 2*. However, Peter found it difficult to concentrate on the assignment and positioned himself as a non-participant through his passive behaviour. After having raised his hand for help repeatedly, he started crying silently and was eventually comforted by the teacher, who sat next to him and tried to help him with the assignment, which he did not succeed in solving. At another point, he dragged his hood over his head, which he placed on the table, thereby signalling that he had given up. In this way, Peter became repositioned from being an in-game expert and helpful support when playing *Torchlight 2* to being a non-participant when given the individual assignment with limited guidance.

7. Discussion

The aim of the analysis has been to show how the tools and learning activities of the School at Play method may reposition students' identities as learners by providing them opportunities for meaningful participation in the classroom. As the examples show, the method involves framing of a number of game-related learning activities – e.g. by explicitly acknowledging commercial games as valid resources for learning, promoting positive behaviour in the classroom through a "school game" (the Token Tracker), allowing students to freely explore and cooperate in order to progress in *Torchlight 2*, and attempting to link the students' game experiences and progress to assignments framed by disciplinary aims. By following Peter's learning trajectory through a game-oriented curriculum, the analysis suggests how these framings and learning activities provide a number of opportunities for repositioning Peter as a legitimate participant in the classroom dialogue, as a game expert and as a supporter for his classmates. However, the examples also indicate how the tools and learning activities of the method may easily be used to maintain Peter's position as a marginalised participant in the classroom. This became particularly clear when the teacher gave individual assignments that required the students to use disciplinary knowledge for analysing a novel, which was based upon a weak thematic relation between being a hero in a novel and a hero in a computer game.

These preliminary findings point to the crucial importance of the role of the teacher in terms of preparing and facilitating game-related scenarios, which confirms findings from other studies conducted by the author (Hanghøj & Brund, 2010; Hanghøj & Hautopp, 2015). Moreover, the findings also indicate the importance of creating meaningful translations of students' experiences from game domains into disciplinary domains. When interviewed afterwards, the teacher and the two consultants pointed out how the *Torchlight 2* curriculum being studied here lacked a more meaningful integration with the curricular aims of the subject Danish. Instead of trying to "match" the game experience with the genre-specific norms, themes and structure of a literary text, the students might have benefitted more from closer analysis of genre aspects of *Torchlight 2* that related directly to their in-game experiences. One approach to create such links would be to adopt a systems thinking perspective, which could help students to understand how digital games relate to disciplinary domains in terms of being complex knowledge systems (Salen *et al*., 2010). Another approach could have been to let the students design different types of "paratexts" (Apperley & Beavis, 2011) such as walkthroughs or game reviews, which should meaningfully communicate the experience of playing *Torchlight 2* to specific audiences. The important point here is that teachers should act as a facilitator, which is able to facilitate and frame dialogue that links in-game and "game-like" experiences to non-game topics – e.g. by relating the game experiences to disciplinary aims or to other types of learning aims in the classroom. As mentioned, the preliminary findings presented here will be further explored through on-going work in a large-scale research project, which applies the School at Play teaching method in eight math and Danish classes (grades 3-6) distributed across four different Danish schools. In addition to providing more detailed descriptions of teacher and student positions, the project aims to explore how the use of games and game elements may support student motivation and self-determination (Deci & Ryan, 2000; Ryan & Rigby, 2010). Finally, the project also aims to study how the method may benefit students' metacognition by providing structured feedforward on visible learning aims (Hattie, 2009).

8. Conclusion

The analysis has shown how the School at Play method frames game-related learning activities through the use of digital games and game dynamics, which may reposition students as legitimate participants in the classroom.

In this way, the method could provide a valuable means for empowering and including marginalised students by providing them with meaningful contexts for learning. However, the findings also indicate that the value and effectiveness of the method is highly dependent upon the role of the teacher in terms of facilitating feedback and dialogue around the students' game-related learning activities. Moreover, there is a clear need for curricular design of learning activities that meaningfully integrate game-related knowledge practices with disciplinary concepts and aims. This calls for more research on the method in order to assess its usefulness.

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Amplifying Applied Game Development and Uptake

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Abstract: The leisure game industry is one dominated by large international hardware vendors (e.g. Sony, Microsoft and Nintendo), major publishers and supported by a network of development studios, distributors and retailers. New modes of digital distribution and practice are challenging this model and the games industry landscape is one undergoing rapid change. The established industry appears reluctant to participate actively in the applied games sector (Stewart et al., 2013). This could be because of the concentration on consolidation of their platforms, content, protected brand and credibility which could be weakened by association with the conflicting notion of purposefulness in applied games in market niches without established return on investment. In contrast, the applied industry exhibits the characteristics of emergence and immaturity ; weak interconnectedness, limited knowledge exchange, an absence of harmonising standards, limited specialisations, limited division of labour and arguably insufficient evidence of the products efficacies (Stewart et al., 2013; Garcia Sanchez, 2013) and characterised as a dysfunctional market. To test these assertions the Realising an Applied Gaming Ecosystem (RAGE) project will develop a number of self contained gaming assets to be actively employed in the creation of a number of applied games to be implemented and evaluated as regional pilots across a variety of European educational, training and vocational contexts. The project brings together twenty European partners from industry, research and education with the aim of developing, transforming and enriching advanced technologies into self-contained gaming assets that could support a variety of stakeholders most significantly, game studios interested in developing applied games. RAGE will provide these assets together with supplementary knowledge resources through a self-sustainable Ecosystem, a social space that connects research, industry, intermediaries, education providers, policy makers and end-users in order to stimulate the development and application of applied games. The authors identify barriers and opportunities in engaging, exploring new emergent business models .

Keywords: applied games, serious games, game assets, ecosystem, gamification

1. Introduction

For some time now games have been employed in education and training settings across a wide and varied range of application domains including most notably and successfully in business and administration, the military, and health care. Proponents have consistently highlighted the enormous potential of games in education and training settings to stimulate engage and motivate (Prensky 2001) , in particular , disaffected learners. Critically digital games have in the past been presented as the panacea for solving the many problems in schools and training sic (cf. Gee, 2003; Quinn, 2005) .There is ,however, an increasing volume of research and validation evidence available to support the notion that games can indeed be extremely effective tools for learning (Connolly 2012). In parallel emerging digital technologies in design, production and distribution have enabled considerable cost reductions in game development production and delivery. In an environment with reductions in costs married with significantly increased capabilities one might have expected to experience substantial growth of the applied games market. However, growth figures of the wider domain of game-based learning, including simulation-based learning are estimated to be in the region of 3-4 % per year until 2017 (Adkins, 2013). In contrast, the leisure games market is experiencing much higher growth which is forecast to continue over the coming years, to an estimated 7 % per year (PWC, 2012). A number of explanations for the cause of this phenomenon in the applied game industry and markets have been suggested. Firstly that , the applied games industry exhibits the characteristics of an emerging, immature industry namely: weak interconnectedness, a very limited knowledge exchange, an absence of harmonising standards, limited specialisations, limited division of labour and insufficient evidence of the products efficacies (Stewart et al., 2013; Garcia Sanchez, 2013) and could, arguably, be summarised, at present, as a dysfunctional market. There is, however, seemingly contradictory evidence to suggest that the exponential social impact of the Leisure Games Industry is leading to a growing acceptance of educational games as having an authentic and legitimate place in the digital game development industry (Hollins & Whitton 2011). Paradoxically; this social impact could have a negative effect on the attraction of the applied games industry to leisure game developers concerned with maintaining their perceived established brand characteristics such as “coolness” , “edginess” or rebelliousness.

Secondly, the education and training market is widely characterised as intrinsically conservative and (highly) risk averse. Over the years, various authors (Bates, 1995; Clarck and Estes, 1998; Westera, 2012) have criticised what is perceived as a conservative culture in educational practice; one that is entrenched historically in the intuitive and traditional pedagogic methods of the pre-medieval apprenticeship model, featuring an omniscient master and a naive pupil. Bates (1995) goes further in critiquing the established organisational model of education itself in the classroom and in teaching in presenting a scathing judgement on the role of teachers, who, he asserts, rarely use any kind of design process and do not ground their work on validated , scientific evidence. Thirdly it is suggested that there is a significant dichotomy between the established and emergent business models of the leisure games industry and the emerging properties of the much less mature Applied gaming markets.

The paper and is a theoretical ; synthesising current theory with practical implementation In the authors will analyse these issues in the context of the RAGE project: Realising an Applied Games Ecosystem. In essence the RAGE project is a technology-driven research and innovation project that makes available accessible self-contained gaming assets (i.e. solutions showing economic value potential) that support game studios in the development of applied games. These assets are made available together with substantial accompanying high-quality knowledge resources through a self-sustainable Ecosystem The ecosystem is a social space that connects a variety of stakeholders from the research, gaming industries, intermediaries, education providers, policy makers and end-user communities. The paper services as an introduction to the RAGE project , its goals assumptions and objectives and as such an underpinning theoretical framework or established research methodology has yet to be consistently defined . The grounded methodology will combine mixed methods to include both quantitative and qualitative analysis of stakeholders, their respective requirements and responses through a series of both structured and unstructured interviews over the intended four year duration of the project, this will be supplemented by participant observation in case study analysis.

In broad terms the project will adopt a critical realist perspective to the project in formative and summative evaluation activities.

2. European objectives and policies (H2020)

The RAGE project is situated and funded as part of the Horizon 2020 European Framework programme for Research and Innovation . This programme is the largest EU research and innovation programme with an investment of 80 billion euros available over the seven years of its intended life-cycle 2014 to the present day. The intention of the programme is to stimulate economic growth through innovation and bring “good ideas” to market quickly, ideas that address real needs by coupling science and innovation in order to boost the European economy and competitiveness in global markets. The programme aims to couple Industry , in particular Small to Medium Enterprises (SME) with academia , innovation blue sky thinking , in order to address real needs in effect creating an innovation union. This activity is characterised by a series of research and innovation pillars namely; excellent science, industrial leadership and investment in industries.

3. The distinctions between the “established” leisure game industry and the applied games industry

The authors assert there are significant distinctions between the Leisure and Applied gaming industries which can be characterised in the following ways :

3.1 The leisure game industry

Digital games have acquired extraordinary social relevance, becoming a highly significant media in modern culture and life and constituting a massive industry with 155 million of users and $22.4 billion per year in the US alone (ESA 2015). There has been a prolific rise in the number of game players of games in particular casual gaming, over the last decade played by an ever increasingly broad demographic audience , in terms of geographic location, age and of both genders over an increasing and varied number of technology platforms including consoles, personal computers, hand held devices and significantly mobile telephony.

However, it seems that digital gaming industry has been primarily remained focused on the development of entertainment products and services . Recent research undertaken by the Entertainment Software Association (ESA 2015), provided data indicating that only small percentage (5%) of the games acquired (purchased) in the United States were developed for educational purposes (Notwithstanding these commercial off the shelf (COTS) games could conceivably have been applied within educational settings).

As suggested in the introduction, anecdotally at least, the established Leisure Games industry has thus far been extremely reluctant to engage in the development of applied or serious games (Stewart 2013). There are a number of real and perceived barriers to active participation by the digital game development industry in applied and serious games markets. As indicated in the introduction of this paper there is a perceived lack of maturity of the Applied Game Market in particular in respect of established business models or clear evidence of return on investment of development costs. Whilst development costs through technology have reduced significantly for some sectors of the market notably with the rise of the use of middleware and small scale App development over the last decade in other segments such as console (proprietary platform technology) the "cost of success" in terms of development, licensing and marketing has increased markedly. The risk and cost of entry to digital game developers in new applied gaming markets is significant.

Leisure digital games product business models can be analysed vertically, or alternatively from concept to market or horizontally (Williams 2002) into market segments. Games have been identified as "experience goods" where quality is determined only through their consumption (Kerr 2006). Historically, in terms of vertical analysis game development has been focussed on large scale, and time consuming two years of development, consolidating proprietary platforms.

A cursory review of the value chain analysis of the the final price of a game a conventional "Commercial off the shelf console boxed game" reveals contribution levels of the console manufacturer (Licensor) 10 % , the Developer/publisher 20 %, the Distributor 6 % , the retailer 14% and finally the customer 50 % (Deutsche Bank 2002).

As discussed, alternatively the value chain can be analyzed horizontally into a number of different market segments. (Williams 2002) divides this into three market segments consoles,handheld and PC's and these into market into percentage market shares whilst others including (Kerr 2006) ,in light of the emergent market conditions of the time including convergence and , adopt a slightly different approach by taking the game "genre" as the starting point; console games, "standard" PC games, Massive Multiplayer Role Playing Games (MMORPG) ,and mini or casual games extending segmentation arguing that a platform based (Williams 2002) approach is unsatisfactory given then the rapid changes to the market and players and emergence of new platforms (and technologies) on a regular basis.

In what is entirely consistent with the evolution of other entertainment industries , such as the music, television and hospitality industries, the ubiquitous effect of digital technology on established Leisure game business models is becoming increasingly evident with the emergence and challenge of new digital distribution and service models. Recent years has seen the establishment of major commercial entities such as Steam offering new cost effective channels to market with service support and active communities of engagement. Established publishers and developers such as Electronic Arts (EA) have responded with the establishment of its proprietary digital distribution platform Origin. A Recent addition to the digital games distribution channels has emerged in the form of Galaxy GOG offering games free of, the highly contentious, imposition of Digital Rights Management (DRM). Galaxy potentially offers some guidelines as to the future evolution of business models . Models that mark a transition from a product based to a service based ecology with foundations embedded within the establishment of a Galaxy online community.

In a competitive and dynamic environment the associated risk of entry to new markets (Applied Games) for digital Games Developers could, arguably ,be the most significant barrier to entry.

3.2 The applied game industry

Applied Games; or at least the more established genre of Serious Games have historically exhibited low production values and whilst there are authors (Whitton & Moseley 2012) that argue "*the opportunity to create bespoke fit for purpose computer games is beyond the technical capabilities and time limitations of teaching staff and outside of the capability of most learning technology teams"* (P 138) and that effective games need games expertise and that many, expensive, in house or designed for education games simply aren't games. (Whitton & Mosely 2012) advocate the value in a low tech approach in claiming production quality has little value in engaging and motivating learners compared to pedagogically sound instructional design and playful approaches.

In direct contrast with commercial entertainment games which are designed to target a wide demographic audience, applied games are usually oriented towards a narrow audience with very specific learning characteristics. They incorporate strong instructional design and pedagogy , andragogy and heutagogy. For example; Unsurprisingly an applied game developed to support the teaching of geology to year four students would be quite distinct in comparison to one designed for undergraduate or postgraduate students studying within a university setting.

Further; applied game development is not only driven by the subject matter but , consistent with the leisure gaming industry, by the intended targeted audience. When an applied game is not instructionally designed in an appropriate and relevant way in terms of pedagogic structure , interface and learning outcomes for its intended audience the result is usually a game that neither engages nor motivates students to play or more importantly achieve their desired learning outcomes. This disjunct results in games that are incomparable with entertainment games (Facer et al,2003; Kinzie & Joseph,2008). This could be further explanation as to why , from the large number of educational games produced there have been few games that users ,or players have a preference for.

Recent research in respect of the effectiveness of applied games endorses this perspective but is inconsistent (Hays 2005; Connolly et al, 2012; Ibanez et. al 2014), highlighting both games with very successful engagement and learning outcomes and others equally where the engagement and learning outcomes have not met expectations. Some authors (Michel D & Chen S 2006) argue that free of the conventional and established business models of the Leisure game industry the applied or serious games industry allows game developers to experiment with (vertical) business and distribution models that bypass the established retail publishing industry and open up new revenue streams.

In contrast to the Leisure game industry in the applied Gaming Industry context quality is not merely determined by consumption. Consistent with most educational interventions efficacy in the achievement of desired pre-determined learning outcomes is the key performance measure and to demonstrate this through evidence based data. Cooperation between these two industries could have an impact in improving applied games quality, and then in achieving better learning outcomes. Applied games industry, because of its youth, would certainly benefit from leisure industry know-how. Many errors that entertainment industry has made over the past 40 years could not be repeated in applied games development.

Applied and Serious games are environments which can potentially support a broad variety of pedagogical approaches including constructivist inquiry based and as didactic instructivist tools (Whitton & Hollins 2008) and have the potential to provide rich streams of real time activity analytical data It should be noted however,, learning and playing are inherently distinct concepts. While learning is readily associated with an obligation - even forced by law - , homework, examinations, are a necessity of life, and a prerequisite for having a job, a salary and a career, games are associated with play, joy, leisure and having fun. In his seminal book "Homo Ludens" Huizinga (1950) describes play as a leisure activity, non-obligatory and fully free of any material goal or interest – no profit can be gained from it. Play cannot be reinforced. Essentially, we are able to force children to go to school or to do their homework, but - in contrast - it is impossible to force them to play. This conceptual conflict forces game developers to deal with applied games and leisure games in different ways. Nevertheless learning and playing share a common base, which is the human need of being challenged by difficult tasks. As Papert (1980) noted: the best fun is "hard fun". Applied games may offer the hard fun that we are looking for.

4. How the RAGE project will address the key challenges

The RAGE project aims to address many of the deficiencies associated with the Business of applied gaming highlighted within this paper with the aim of stimulating growth of the capabilities and markets within the European Union and consistent with the objectives of the EC Horizon 2020 Research and Innovation programme .

Over a four year period the RAGE project will develop an accessible repository system for the curation of a cluster of gaming assets. Initially the repository will house thirty six self contained reusable interoperable gaming assets produced within the RAGE consortium , detail of the asset functions is provided in Figure 01 below; assets that will facilitate the development of Applied games. An asset is described as specifically within the context of the RAGE project as advanced game technology modules (software), enriched and transformed to support applied games development. A RAGE asset is composed of one or more software components working together on a dedicated task. That is, software components are the subordinate constituents of an asset.

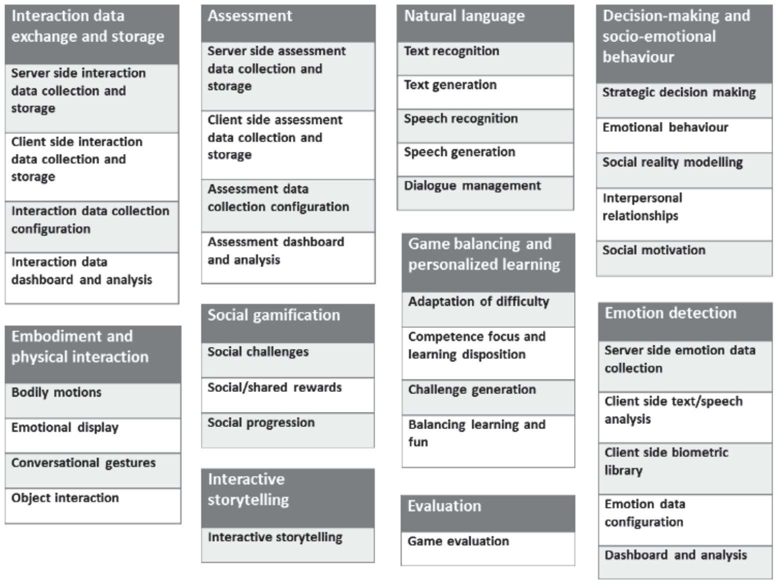

Figure 1: Overview of RAGE gaming assets source RAGE proposal

The RAGE-project is founded upon a number of underlying principles that can be summarised as follows:

- The project will provide an ecosystem with future proof features. Usage of large asset repositories have an inclination to decline in use over an extended period of time with . RAGE will support the social dimensions of stakeholder interaction in order to empower the collaborative process via the asset repository.
- creating and stimulating the Internet Value Chain. A knowledge and technology juncture point for stakeholders available for those organisations on the applied gaming supply side (industry, universities, …), and for those organisations on the demand side (end-users, organizations,...).
- By involving Universities as an integral part of the innovation process model; consistent with the Triple Helix model (Leydesdorff & Etzkowitz, 1998),. of government , industry and education .A stated objective of the RAGE project.
- Enabling the disruptive power of small medium enterprises (SME). History demonstrates , small companies in the leisure game industry have been at the forefront of innovation in the industry tackling the development challenges . Larger developers, in general, are accommodated within an incremental model which can restrict innovation and appetite for risk. The RAGE ecosystem aims to facilitate the gaming creation process for small companies .
- With the pilot implementations and case studies targeting employability skills specifically aligned with the objectives of the European Commission Horizon 2020 ambitions. The applied games produced in RAGE will address unemployment problems by creating accessible and usable tools that educate in clearly targeted broad social and employment requirements ; that addresses the challenges of social exclusion and improve retention in education or training . Research paradigms are combined to ensure that innovative and usable assets are developed
- The project will combine design-oriented (to make them better), intervention-oriented (to make them work), domain-oriented (to make them matter) and disciplinary research (to make them understandable).
- By focusing on the ecosystem's usability from the game developer perspective ; having access to advanced gaming technologies should not be an issue in the future . By producing interoperable assets both culturally and technologically , integration or communication within or with systems will be greatly enhanced. RAGE is determined to create easy to use technology, by developing assets with pedagogical guidance.
- By addressing the Gaming priority areas. The asset components in RAGE will be: relevant for learning, advanced, and work in games where there may be challenges.

5. The conceptual underpinning and management approach in RAGE

The transformations from leisures game technologies into applied gaming functions are indicated in Figure 02. That Figure 02 summarizes what leisure industry techniques should be transformed to create engaging, pedagogical and capable to analyzing applied games.

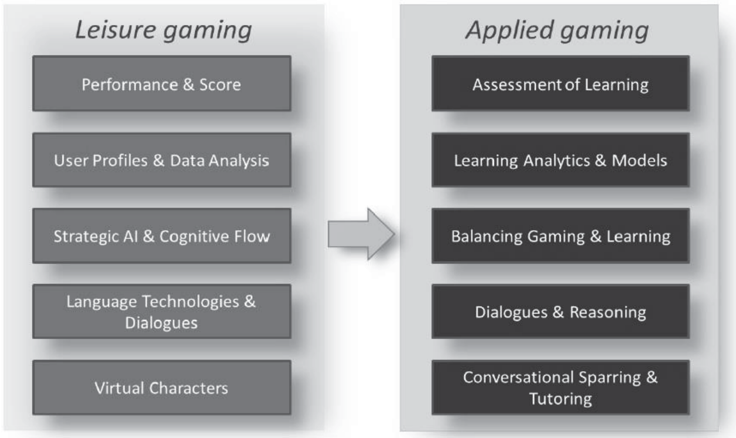

Figure 2: RAGE: Transforming leisure industry technologies to build applied games. Source: RAGE proposal

The RAGE ecosystem aims to replicate the elegantly aesthetic structure and self regulating principles of a natural ecological system providing an architecture for innovation hence the term “ecosystem”.

6. Discussion and conclusions

The conceptual underpinning and strategic approach to the project in particular developing an “ecosystem” , a metaphor derived from the work of (Moore 1993) , is based on the premise that agents are embedded in a competitive business environments that inherently must coevolve in developing symbiotic relationships with other agents or stakeholders learners, customers, those in the supply chain and their competition . The concept is well established within information technologies industries with perhaps silicon valley as the prime example of a fully functional business ecosystem. Specific examples exist within the game development industry itself with Unity asset store. A significant challenge and in equal measure ,strength, of the approach is to ensure that asset development embraces both user and developer demand and equally is able to stimulate innovation and creative embedding of the pedagogical requirements applied gaming in the specific use cases by the game development community *crossing the chasm* (Moore 1991) and diffusing innovation (Rogers 1962) recognising the significance of cultural and social interaction in ensuring innovation activity and early adoption (early adopters) is embraced by the domain pragmatists (early majority) which will ensure the sustainability of the ecosystem itself.

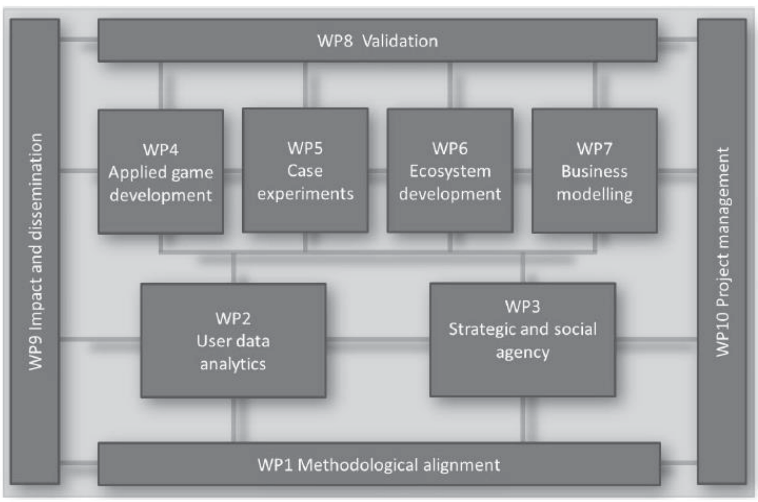

Figure 3: Representation of the interconnections of the RAGE project work packages source RAGE Proposal

Figure 03 is a visual representation of the design of the workpackage and their associated interconnections essentially a series of discrete activities pressured by method/ project alignment and impact and dissemination.

The RAGE project will develop entirely new and accessible supported services and interoperable assets with the objective of bridging the chasm that currently exists between the Leisure and Applied Gaming industries. Barriers , both real and perceived , the cost of entry and consequently risk will be significantly reduced. These assets, when employed, will significantly reduce the cost of production of high quality applied games incorporating hitherto complex pedagogic functions such as learning analytics, learner agency, assessment, and artificial intelligence validating the quality and efficacy of theses assets by testing them in a series of large scale game pilots. The RAGE project will support this development by undertaking extensive research in to the established Leisure Game Industry and emerging Applied Gaming industry business models to provide leverage points for developers engaged or seeking to engage in the Applied gaming market.

These assets and their ultimate location in a supporting ecosystem incorporating supported stakeholder demand and supply side agency should ensure both scalability and sustainability with the aim of supporting an increasing number of Leisure game developers active in the applied games market over and above the ten percentage (Games Monitor 2012) of those companies participating at present.

The RAGE project thus aims to accommodate and amplify the Applied Game market by making available advanced and portable technologies for applied game development. The actualisation of this goes with substantial challenges. At the technical level big efforts are needed to realise assets that are both feasible, interoperable, useful and usable. Also the technical design and integration the Ecosystem as a social space along with an extended repository of gaming assets and other gaming resources is anything but straightforward. Empirical research is needed to validate the pedagogical value of designed assets under practical conditions, that is, in experiments and real-world pilots with end-users. At a practical level, the RAGE project will connect to a wide range of Applied Games stakeholders, in particular game industries, game developers and game researchers for creating a critical mass in Applied Gaming. Research into business models will be essential for the fruitful adoption of new technologies and methodologies.Finally, the Ecosystem itself needs to go with a feasible model for sustained exploitation

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Playing Facilitators: Care and Tough Love in Games Based Learning Contexts

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Abstract: This paper presents reflections on the role of teachers as facilitators, in a context of role-play targeting learning of design thinking skills. Our study was conducted according to the method of visual ethnography. We acted as facilitators for 50 students through the yearly six-day competitive event called *InnoEvent*, addressed to students in the fields of multimedia and healthcare. Being interested in studying games and role-play as tools to support independent learning in the field of design thinking and team-building, following Dewey's (1938) theory of learning experience, we ran two workshops based on two classic role-play games: *The Silent Game* (Brandt, 2006) and *The Six Thinking Hats* (de Bono, 1985). These games were created to support students in learning design thinking in groups and are assigned positive values in literature, hence we expected a smooth process. However, our experience was rather characterized by conflictual negotiations with the students. Data from our observations and from interviews with group representatives show that the students took a discontinuous learning path, characterised by a false start, failure, and a thorough reconsideration of their work, succeeding in the end to produced original concepts. At the same time our role as facilitators shifted from instructional carers to challenging, and to group leaders. Based on our evidence we propose a new perspective, in which conflicts are an integral part of games based learning and can deepen the dialogue between students and facilitators, setting the conditions for independent forms of learning.

Keywords: role-play games, design thinking, facilitation, learning experience

1. Introduction

The application of games, whether digital or not, in learning practices is expected to elicit: engagement, focus, and active participation, as games are appealing for young people and can support different learning styles (Tang et al, 2008). Moreover, from a pedagogical perspective, games based learning is seen as a concrete application of the principles of activity theory, in which learners can engage in forms of learning by doing (Tang et al, 2008; Resnick, 2004). This paper proposes a new perspective, investigating how facilitators can support learning when games fail to elicit engagement.

We explore in our study how games can contribute to create learning experiences, in which students can face the learning content and think on their own (Dewey, 1938). Our study was conducted during the yearly six-day event called *InnoEvent*, involving 500 young students in the fields of multimedia and healthcare. We acted as facilitators for 50 students, divided into 6 groups of 6 to 7 members. In order to stimulate the students' process in design thinking and team-building, we ran two workshops based on two classic role-play games: *The Silent Game* (Brandt, 2006) and *The Six Thinking Hats* (de Bono, 1985). Moreover, we supported the students in their creative process, providing feedback through the whole week. We considered these two games as valuable tools to support the students in engaging in learning by doing and in enabling them to discover what design thinking is and how it takes place within group work.

Contrary to our expectations most students receive the two games with a negative attitude and did not take the two sessions seriously. As a result most groups failed to deliver original ideas, hence we shifted our attitude from caring to tough love to help them succeeding in the competition. This paper presents theoretical reflections on the complexity of the role of teachers as facilitators, in a context of role-play learning targeting design-thinking skills.

In the following sections we discuss our related work (2) and the methods adopted in our study and the specific context (3). Section 4 provides a discussion about the data collected through our study, finally section 5 presents conclusions and future work.

2. Related work

Current literature associates positive values to the use of games in learning, claiming that digital as well as non-digital games introduce playful elements, enabling students to actively engage in learning by doing. As Resnick (2004) states, the integration of play and learning enables new ideas to emerge, being tested iteratively and refined. This principle has its roots in activity theory, for instance in the studies conducted by Vygotsky (1978), who claims that social and solitary play fosters forms of conceptual thinking, through reflections on the implications of possible actions in play. Researchers like Iversen and Buur (2002) argue that games offer an appropriate environment to learn participatory design practice, supporting students in understanding the social aspects of design practice and in nourishing "reflection in action" (Schön, 1987) for beginners to experience design practice.

At the same time games-based approaches to learning can be analysed from the perspective of inquiry-oriented learning, proposed by John Dewey (Harr et al, 2008). According to Dewey (1938), students learn through a continual construction and reconstruction of learning experiences, engaging in making multiple choices among competing lines of actions. In this way children learn through engaging in experiences and in making evaluations on their actions and those of their mates. However, games are not always acknowledged as coupling learning with engagement (Harr et al. 2008), as in some cases games were perceived as hindering the emergence of meaningful reflections on the learning process, because of discrepancies between learning and games goals.

Our goal was to elicit a meaningful learning experience, in which students could reflect on their process based on previous experience, opening up towards continuous growth and new experiences (Dewey 1938). On the contrary mis-educative experiences elicit indifference to new experiences hindering growth and development of new knowledge (Dewey, 1938).

In our study we adopted *The Silent Game* (Brandt, 2006) and *The Six Thinking Hats* (de Bono, 1985) in the first day of the *InnoEvent*. Both games are assigned positive values in literature, for instance Darsø et al (2004) recommend The Six Thinking Hats as a tool to enable students to engage in a creative learning process.

The Silent Game is concerned with design theory, where design is seen as a practice of "dominance" and "territory", in relation to how designers communicate with each other and participate in design practice (Brandt, 2006 p.58). The players can communicate only through their design moves, as they are not allowed to speak to each other. The first player has to invent a pattern, while the second player must try to understand the pattern and expand it or invent a new pattern for player one to follow. According to Brandt the game pieces can be anything from pieces of wood over nails to buttons in various size and colors, but it is important that the players have a large array of game pieces to choose from, so that they can copy from one another (Brandt 2006).

Edward de Bono (1985) is the author of *The Six Thinking Hats*, a method for idea generating targeted at design teams. Each hat is associated to a color and to a specific role, related to a different perspective on the design process: the white hat is associated to facts, the red one to feelings, that black hat to drawbacks, the green hat to new ideas, and the blue hat to the overview and aims at securing that the guidelines of the methods are observed (de Bono, 1985). The method prescribes that the attendees take one of the different hats and play in turn each of the different roles, in order to conduct a thorough reflection on the design process.

These games are praised for boosting creativity and for enabling designers to engage in design intended as a social practice and for introducing motivational factors in learning situations, introducing challenges and social interaction (Tang et al, 2008); in this respect, they seemed appropriate to be introduced to our students during the *InnoEvent.*

3. Method: Data collection and analysis

The study followed an ethnographic approach (Pink, 2006), we observed and filmed the students, taking notes on a diary and took pictures while the students engaged in the games and during collective feedback sessions. Later on we analysed our recordings following the principles of visual ethnography and interaction analysis (Jordan and Henderson, 1995), we focused on analysing the students' tone of voice during conversation, their verbal and non-verbal interaction (facial expressions and physical gestures), to investigate how they contributed to the artefacts they were creating during the game sessions.

Since the beginning of the week we informed our students that we were conducting a study on the use of games in learning and that during the *InnoEvent* week we would do some observations and video-recording of our sessions. In this way we tried to respect the principle of procedural ethics in qualitative research, according to which the researchers have to avoid harm and deception, negotiate informed consent and ensure privacy and confidentiality (Tracy, 2010 p. 847). This means also that the participants have the right to know the nature and potential consequences of the research, so that they might give their consent or refuse to participate.

During our study we observed how each group worked together and related to the tasks. We also took pictures of the artefacts they produced during the game sessions, and analysed the aesthetic of the artefacts as revealing how the interaction unfolded among the different individuals.

On the final day of the event we held interviews with representatives from the different groups. The aim of the interviews was to find confirmations or disproves of our initial findings on the students' learning experience. The interviews were held with 2 representatives each time and in a structured form (Silverman, 2005), so that the questions were written down before and iterated, in order to invite the students to reflect on each day of the event. The questions focused on discussing specifically if the activities set for the different days were perceived as useful by the students, their main challenges and foci for each day, and which changes they might suggest for the next *InnoEvent*.

3.1 The setup of the study: Innoevent, design games and design thinking

Our study was conducted during the yearly *InnoEvent*, a competition, in which groups of students coming from different educations have to design an innovative solution that leverages on digital technologies in order to support users dealing with different issues. The event is based on a user centred design approach to innovation, in which the students are supposed to create solutions that should improve the quality of life of their users, usually a local institution, through an iterative design process (Preece et al, 2011). The framework of the event includes elements of gamification (Deterding et al, 2011), as the event is characterized as a competitive game including rules, small challenges, and social events to which the students have to attend[1]. The winner is decided on the 6th day, when the students are supposed to present their concept and show their final prototype; the best project is decided by the votes of a committee including the involved users, teachers, and representatives from local companies.

Each year the *InnoEvent* has a different theme with multiple challenges, this year it focused on creating solutions to support patients recovering from different conditions. Our groups cooperated with a nurse from *Dallund Castle*, a facility located out of Odense (Denmark) where patients recovering from breast cancer receive treatments, physiotherapy, and psychological support followed by nurses and therapists. We worked with 6 groups of 6 to 7 students; through the week we functioned as facilitators and consultants, helping the students in their design process.

During the first day we ran two workshops based on the classic role-play games *The Silent Game* (Brandt, 2006) and *The Six Thinking Hats* (de Bono, 1985), in order to stimulate the students in their creative thinking and team-building processes, and also to set conditions for learning experiences encouraging learners to engage in independent social inquiries (Dewey, 1938). These games fit well with our approach to design teaching and practice, and seemed to add values to the gamification structure of the *InnoEvent*.

The first workshop was based on *The Silent Game*, which was intended as a team-building activity, to enable our students to experience creative thinking as a social process within their newly created groups, before they actually started to design. However, because of practical constraints we were forced to modify some of the elements of the game from its original description (Brandt, 2006), where it is stated that only two persons should be playing together and that they should be able to choose from a lot of different materials. As the aim of our workshop was to support the team building process for our groups and we had positive experiences with applying this game to larger groups, we invited all 6 or 7 students in each group to play together. Moreover, the students only had access to *LEGO* bricks in different colors and shapes. Following the rules of the game, we told the groups that they would have to appoint one of their team-members to be the "leader" of the group, while the others would play the role of designers. The designers started by building a pattern with their *LEGO* bricks

[1] For more details: http://innoevent.dk/process (last seen on the 20th May 2015)

without talking to each other for about 10 minutes, afterwards the leader was supposed to expand or change the pattern according to his/her vision for other 10 minutes. This dynamics was iterated about 3 times and was aimed at supporting our students in reflecting about their role within the group, about how they could make their individual vision fit within a social design process.

After this workshop we introduced de Bono's *The Six Thinking hats* (1985), and we invited the students to reflect on the artefact they had created during *The Silent Game*. Also in this case we had to tailor de Bono's method to the situation, since we wanted the students to experience the six different thinking directions defined by de Bono in the given time, we provided each group with a series of 6 *LEGO* bricks each in a color corresponding to one of the six thinking hats (black, blue, red, white, yellow and green). We also asked the students to start working on their concept for the competition and comment on their artefact playing one of the six different roles identified by de Bono and picking a *LEGO* brick of the corresponding color. Moreover, the students had to write down their comments and suggestions for design on an A3 sheet with markers. After each session we held a sum up discussion with the students to reflect on their process.

In the following chapter we discuss our findings from the workshop in relation to the students' responses (4.1) and also to our role as supervisors and facilitators (4.2).

4. Discussion: Games and disengagement

The two workshops had several purposes for us, as teachers and facilitators, the first and most important purpose was to support the students in their process of team building, as they did not know each other. Secondly we expected that the two games-based workshops would have enriched the process of creative thinking for the students, encouraging them in exploring original ideas in a playful way within their groups. At last, we wanted to evaluate if and how the two workshops could push the students in their learning process, so that they might gain new knowledge about the social and creative aspects of design practice in interdisciplinary teams and on an independent basis.

As facilitators we were challenged by the students' response, as at first they did not seem to enjoy nor take the workshops seriously. For this reason a new direction for inquiry emerged as we investigated how learning can emerge in games based learning contexts, when games fail to create engagement. After we introduced the first team-building activity (*The Silent Game*) all the groups seemed to have lost engagement and looked a bit confused, nevertheless they engaged in the task. However, it was difficult for us to understand in situ if the workshops have fostered or hindered learning experiences, hence combining data from the analysis of the video recordings and form the final interviews enabled us to gain a clearer overview on the students' process. From the videos we noticed that the students who were given the role of leader in *The Silent Game*, were active and watched the building process closely until it was his or hers turn to continue. Interestingly, in some groups two students were appointed as leaders, so that they worked together in silent when rearranging the work of their mates; sharing leadership gave these students an experience that was closer to that of their "designer" mates (Figure 1).

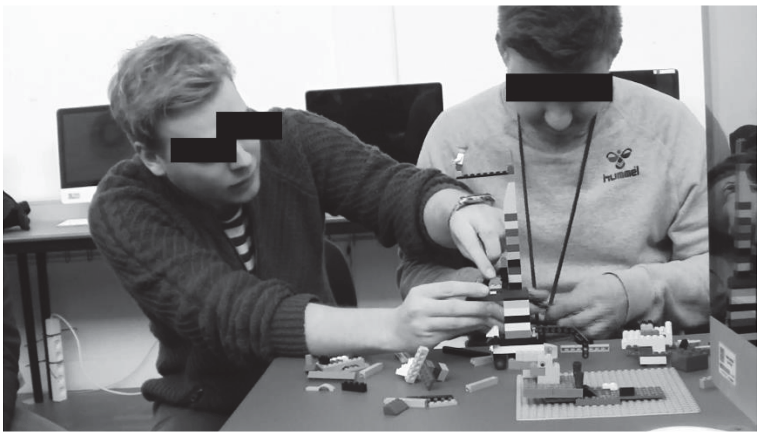

Figure 1: Leaders cooperating at their task

In some of the groups the team members worked individually on different projects until the last round, where they combined them together into one figure, instead other groups worked together on a common project right from the beginning (Figure 2).

Figure 2: Students working at the same artefacts

These different strategies emerged also as a response to the physical arrangement of the room, so that in some groups the designers worked individually on their own table, but turned to each other when the leader(s) had to rearrange their work and used a chair as a shared surface to show their artefacts (Figure 3).

Figure 3: Students combining individual artefacts on the same chair

These different behaviours were interesting from our perspectives as they emerged through a form of social, non-verbal reflection in action (Schön, 1987), as the students did not talk to each other but achieved a tacit agreement on how to deal with the physical constraints of the environment, intended as a resource for learning and social interaction.

In the end of each workshop, the students analysed differently the relation between the designers and the leaders: for instance the members of a group that did not really engage in the activity, said simply: "We just made it!". Other students added deeper reflections, saying for instance: "We got mad!" explaining that they were annoyed by the leader's interventions. However, one student said that it was not a major problem as: "I could change it back to the way I wanted it." This statement shows that some students did not understand or willingly challenged the notion of team-building. In another case the students commented positively on their leader as: "He did not change but added!" as if the leader's interventions were seen as a contribution and not as interference. We consider that in this group the students really started to reflect on their role within the group.

During the sum up discussions and the conclusive interviews, we received conflicting comments on the workshops. Some students claimed that through *The Silent Game* they "became a team" because it offered the opportunity to get to know each other through their creativity. Others instead criticised *The Silent Game,* but said that *The Six Thinking Hats* enabled them to engage in a shared creative process. Despite the initial difficulties, comments gathered during the final interviews are in line with literature on games (Brandt, 2006; Iversen and Buur, 2002), claiming that games enable students to experience design as a social practice reflecting on how they can contribute as individuals.

However, critics were raised also on our way to run *The Six Thinking Hats* activity, when two students said that they found awkward to have to pick the colored *LEGO* brick in order to express their opinion. These comments lead us to reflect on how our particular way of introducing these games have elicited conflicts and a critical attitude in the students. For instance in our version of *The Six Thinking Hats* the students were supposed to pick a *LEGO* brick instead of wearing a hat. According to de Bono the colored hats are symbols of different thinking roles, so that by switching among the different hats, people can explore different trades of thinking and affect a meeting or brainstorming process (de Bono, 1985). At the same time wearing a hat is an obvious reference to role-play, fostering a specific mood and social interaction, so that it cannot be easily replaced by a *LEGO* brick.

Some students criticised *The Silent Game* workshop for imposing silent interaction and for the lack of adequate tables and space. However, interviews and observations show that our adaptation of *The Silent Game* to larger groups emphasised the social aspect of design practice, fostering shared forms of reflection in action that could not have emerged only involving pairs.

Taking a broader perspective on the *InnoEvent*, we argue that its framework might have hindered the emergence of students' creative thinking. The students had their focus on developing a product and were eager to follow the given rules and schedule, so that the framework of the event seemed to have transformed our students into pupils, leaving little space for the enriching learning experience. In these conditions, we found it hard to emphasize the importance of creative thinking as a useful tool in this process. In this respect we found a discrepancy between our goal of fostering creativity and the framework of the event; as Darsø (2011) writes, it is important that the entire organization is aligned to the innovative process and is supporting it, otherwise the enthusiasm disappears and the participants will start to act and do as they normally do.

4.1 Facilitators' roles: From care to tough love

Looking into our role as facilitators, we noticed that the students responded to the games with a negative attitude and experienced an initial failure. After the second workshop we invited the students to present their first idea to us and the other groups: here they noticed that they all come up with the same concept – an app or software providing the patients with a social network or reminding them to do their exercises. As a result, we as facilitators changed attitude shifting from care to tough love, in the sense that we forced the students to face their failure and challenged them to reconceptualise the patients' therapy and explore various forms of interaction. The students seemed disappointed and uneasy, one of the groups said out loud that they wanted to leave the classroom to generate new ideas. We interpreted this as a healthy reaction to a potentially mis-educative situation, defined as a situation that "has the effect of arresting or distorting the growth of further experience" (Dewey, 1938 p. 13). During this process our role changed back from challenging the students, to caring facilitators the students could choose to turn to. Through their initial failure the students also changed attitude and became more serious in their process. At this stage they engaged into a social process that leads toward continuous growth, using the teachers as "leader of the group" (Dewey, 1938 p. 66) and turning a potentially mis-educative experience into an educative one. Comments gathered from the final interviews confirmed this shift:

> *"On the first day we used it (supervision), by listening to what you said, because we were sure you had an intention to what you said. In the following days we worked independently and did research on our own – and sought information from professional experts."*

All the groups worked and participated in the role-play and some groups re-evaluated positively their experience with the games saying that:

> *"It was helpful to play The Silent Game – we found out that we could cooperate although we didn't knew each other. We found out that we could contribute with something and improve the solution. It worked well as team building. The Six Thinking Hats (was) a new concept (that) we didn't know. It was funny because it gave us an idea of how a person might think about a subject. It helped us to focus on certain ideas."*

Data gathered from our observations and interviews with group representatives suggest that the students took a discontinuous learning path consisting of:

- False start
- Failure

- Thorough reconsideration of their path

On a parallel plane our role as facilitator changed from:

- Carer – when we introduced the game and supervising their process
- Challenging – when we forced the students to face their failure with the first presentation
- Group leaders – when the students came to us and we encouraged the students to challenge the experts' guidelines

During the second presentation the students proposed original ideas that met the expert's needs, such as a digital game for physical training to support physiotherapy and a wearable solution to relieve pain during and after the patient's training. This second concept actually won the competition.

Based on our evidence we propose a new perspective, in which conflicts can be functional to games based learning, creating conditions for a dynamic reflection in action (Schön, 1987) and independent forms of learning (Dewey 1938). In the end the selected games were said to support group forming and reflections on the social aspect of design practice, emerging from a shared creative process. The initial failure was central in enabling the students to take charge of their work and of their needs regarding supervision.

In this respect our study is more in line with research critically approaching the relation between learning games and engagement (Harr et al. 2008), however, in our case discrepancies might have laid in the framework of *InnoEvent* and not in the games.

Our perspective also sheds a different light on the role of the facilitator in the case games are met with a conflictual attitude on the students' side, who has to shift from a caring to a challenging attitude, forcing the students to face their failures and search for a meaningful learning experience. A positive outcome was identified as one of the students stated: "I do not care about the competition I want to come up with a solution that can create a difference for women who suffer from breast-cancer." Our findings can be analysed rephrasing Dewey (1938) so that the belief that all genuine and good education is a natural impact from experience involving play or games, does not automatically mean that all experiences involving games or play are genuinely or equally educative. Experience and education cannot be directly equated to each other. However, potentially mis-educative experience can have:

> "the effect of arresting or distorting the growth of further experience. An experience may be such as to engender callousness; it may produce lack of sensitivity and of responsiveness" (Dewey, 1938 p. 13).

Such an experience, however, can also foster learning, when learners and their facilitators enter in a negotiation enabling learners to re-consider their learning path.

5. Conclusions

The study discussed in this paper proposes a new perspective on the use of games in learning contexts, based on Dewey's theory of learning experience (Dewey, 1938), investigating how learning can emerge in games based learning contexts, when games fail to create engagement. Hence we investigated how games for creative thinking and team-building could contribute to the students' learning and creative process.

Despite positive previous experience and literature arguments in favour of games based learning activities as eliciting engagement and motivation (Tang et al, 2008), our results are in line with studies critically reflecting on the relation between engagement and games (Harr et al, 2008). Our students received games activities with a negative attitude and engaged in a conflictual learning path. Through this path both facilitators and student groups encountered a series of three stages. The roles of facilitators and students were complementary on parallel planes and allowed the students to become independent responsibility to be transferred progressively more to the groups (Dewey, 1938), after their initial "failure". Hence, we and our 6 groups formed a larger group that shifter roles in their interaction through the whole process.

Further work could investigate similar game based learning contexts, from the point of view of social interaction and dynamics between facilitators and students.

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The Application of a Content Independent Game Framework in Higher Education

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Abstract: Gamification is a current trend in the business as well as the educational sector and is increasingly being applied in various disciplines and learning settings, especially in the context of e-learning. In order to take the various needs and requirements of learners from different disciplines into account, a concept called Content Independent Game Framework (CIGF) (Korkut et al., 2014) and a corresponding online learning web platform called Tourney (http://www.tourney.ch) have been developed for the application in the context of higher education. According to the concept, teachers on the one hand, are content experts and mentors for the learning process. The students, on the other hand, are explorers, achievers and individual learners. For this reason, according to the CIGF, teachers act as game designers, creating playful challenges based on their subjects and geared to their students' needs. How difficult the game level is designed and what knowledge is to be imparted in which way depends on the teacher's evaluation, expertise and imagination. The application of the CIGF aims at engaging students in online learning environments as well as motivating instructors to rethink their content and design it in a new, attractive way to comply with the prerequisites of the digital age. The paper introduces the concept of the Content Independent Game Framework and the respective online learning platform Tourney and describes different use cases in the context of higher education. Furthermore, the different types of user data collected with Tourney as well as game stages designs are presented. Gained experiences from these game stage designs with regard to the underlying learning strategies as well as learning outcomes from user observations are reported and discussed and a future outlook is given.

Keywords: game framework, gamification, game-based learning, game design, e-learning

1. Theoretical background

The digital transformation changes the educational design and structures fundamentally, particularly the process of teaching and learning. With rapid developments in the area of e-learning there is an increasing need to develop user friendly, attractive, effective and thoughtfully designed applications that support learners as well as teachers (Ardito et al., 2005). Information and communication technologies offer new ways to enrich teaching and learning as well as support the acquisition of knowledge and the interaction between students and teachers. Design and visualizations contribute strongly to the effectiveness of these digital learning environments. Gamification describes the use of game elements in a non-game environment (Zichermann et al., 2011). Gamification and game-based learning are trends that are meanwhile seen as potentially effective methods to improve and support learning and engagement in online learning environments (Buckley and Doyle, 2014).

However, ongoing research and development in this area is important in order to thoroughly understand the requirements for an effective application of gamification methods and to develop tools that assist students to increasingly determine and assess their individual learning process in the e-learning context. Hence, there is a shift from unidirectional and conservative learning instruction towards more interactive and information-rich learning settings in online learning environments (Webster, 2015). Providing learners with individual feedback for their learning progress, formative and summative, is one of the most important aspects of learning support (Issa et al., 2014). In turn, immediate feedback is also a prime feature of games, which is why they can be a useful tool to support the learning process (Vasilyeva et al., 2007).

The effective application of gamification in the university context is a current challenge, because of the novelty of the approach and the lack of long-term studies and evaluations. There are, however, various approaches and use cases for different disciplines (Iosup and Epema, 2013; 2014; Wood and Reiners, 2012). In order to apply gamification effectively it is of utmost importance to understand the target audience and their needs as well as the specific context of education and the learning process, respectively the progress in class. Game-based learning is the use of games to impart knowledge, skills and abilities to learners using self-contained space (Kapp, 2015). The use of games in a learning context is supposed to provide an experimental environment, increased motivation and an improved focus during the learning progress. Any negative real-life impacts should be minimized or completely eliminated (e.g. bad grading, punishment) in order to provide a safe environment (sandbox). Therefore, the challenges should neither be too hard nor too simple for the students, leading to higher concentration and longer involvement with the activity (Csikszentmihalyi, 1990). Gamification has the potential to transform student assignments into challenges that trigger motivation and engagement (Larsen et al., 2012).

When it comes to learning performance it is necessary to keep track of the personal learning progress and development. Feedback on the learning progress in education is usually provided by conventional grading systems, which are based on predefined achievements. However, those are often not adjusted to the individual needs, skills and interests of learners. In order to take these individual skills, competences and different ways of learning into consideration and to support self-reflection it is important that users receive valuable feedback on their learning performance (Nicol and Macfarlane-Dick, 2006). Gamified online learning tools can support that goal (Wood et al., 2013). The data collected from the traces people leave in online environments can be a valuable source of information and a helpful basis to provide individualized feedback for the learning progress. Additionally, the data can help to identify new patterns of learning in digital learning environments.

2. The content independent game framework (CIGF)

The idea for the development of a Content Independent Game Framework (CIGF) stems from a research project with the goal to evaluate playful and interactive learning environments for students and creating new concepts with regard to their application in higher education. This research project was an interdisciplinary collaboration of experts from the Schools of Business, Engineering, Academy of Art and Design, Applied Psychology, and Education of the University of Applied Sciences and Arts Northwestern Switzerland. The diverse input generated by people from the different disciplines contributed to the idea to create a framework and a gamified learning tool that can be applied in every educational context and discipline.

As a basis for the development of the framework the following statements with regard to games in the context of learning were collected in an internal workshop during the research project:

- In teaching, games should be used mainly in the preparation, learning and repetition phase, not in the context of exams.
- A game should be a safe environment, where no negative consequences on the reality are to be feared (Sandbox). E.g. if the game identifies a student's knowledge gaps, the student should not be given a lower grade, but being increasingly supported in that knowledge area.
- A game in education should represent a test platform for skills and abilities as well as for the self-evaluation of knowledge.
- A learning game should give direct and easily understandable feedback on the individual performance.
- It should be possible to play learning games both inside and outside of the classroom.
- It should be possible to play learning games on any common device any time.
- The games should be played, developed and enhanced by the game developers, teachers and students together in order to make them suitable for the respective target groups.
- Playful elements, challenges and surprises should be part of the games.
- The basic motivations to be triggered should be fun and curiosity.
- Learning games should trigger reflection and support the learning process.
- Learning games should provide guidance and structure in order to achieve the desired outcomes.
- Learning games should be goal-oriented and carefully integrated into the overall learning design of the different classes.

From these requirements and several principles of gamification as well as motivational theories the concept of the Content Independent Game Framework (CIGF) has emerged. A major input for the framework comes from the idea of playing with LEGO®, where single pieces can be assembled in a pre-defined way, but the outcome, interpretation and the final structure are completely autonomous, personalizable and undefined. LEGO® bricks can be put together in countless ways and the emerging designs and architectures can represent any content and meaning given to it. Furthermore, the CIGF as a framework is based on the understanding of teachers as content experts. They know their subjects best as well as their students' needs. In order to enrich their classes with playful challenges and innovative technology, the identified requirements with regard to games in education have been structured, conceptualized and technologically implemented as an online learning game platform called Tourney. The LEGO® idea has been used as a basis for the platform, which enables learning game creation through the provision of necessary modules and game mechanics. Teachers can transform these modules into game stages that support the learning goals of their classes.

The underlying idea of the CIGF is to enrich classes by applying game-like activities and integrating them into the learning design in order to increase fun and motivation as well as to make the learning experience more diverse. Additionally, it makes use of the concept of mobile learning, since it enables the use of devices such as tablets and smartphones, which many learners increasingly use to communicate, learn and retrieve information.

3. Tourney - a content independent learning game platform

The name Tourney is a combination of the words "tournament" and "journey", which both represent gamified elements of learning. The online learning game platform Tourney (Figure 1) is a digital game framework for individual learning game creation. It provides all necessary modules for the generation of learning game stages without predetermining any content, so that the game designers (i.e. teachers) can create game stages on the basis of their own structured materials and class-relevant information. The platform offers a flexible and multifaceted tool-kit of self-learning sequences and game mechanics that teachers can assemble and enrich in order to create learning paths by choosing and arranging modular elements. A game stage can be formed by using these predefined modules and assigning course related information and learning material to them. The integrated learning content can be of the following type: questions, texts, attached documents, Internet links, videos, pictures, drawings, etc. This variety of options provides a common ground for the learning game creation in different settings and for different goals. Hence, an important benefit of Tourney is the fact that it can be widely applied due to its versatility, flexibility and neutrality.

As soon as the game creation process in the level editor is completed, the game stage becomes available for the users to explore. The learners then fulfill the predefined requirements of the learning process, such as watching course material, reading lecture notes, answering questions, uploading texts, photos, videos, etc. Furthermore, the players gain points and items (immediate feedback for the learning quantity and quality), keep their characters' health level at optimum (learning efficiency) as well as monitor their own learning progress (Korkut et al, 2014).

The gamified learning platform Tourney has been developed with the goal of providing a flexible and expandable tool that on the one hand enables learning game creating for the application in classes and on the other hand allows for data collection of learning data as well as research on learning game design and feedback mechanisms in online learning environments.

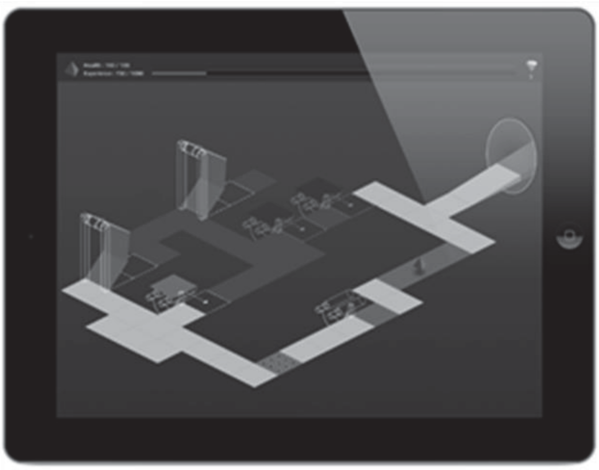

Figure 1: Screenshot of the learning game platform Tourney (http://www.tourney.ch)

4. Collected learning data

In the current productive system of Tourney, data from various system interactions with the users is being collected. These basic data sets are a preliminary output and not yet fully available for the players and the teachers, but they are systematically evaluated for research purposes as well as the further development of the system. Tourney's current prototype report function has two possible overviews: question-focused and player-focused view. This already offers the opportunity to analyze user data from these two perspectives, as shown in Figure 2 and Figure 3.

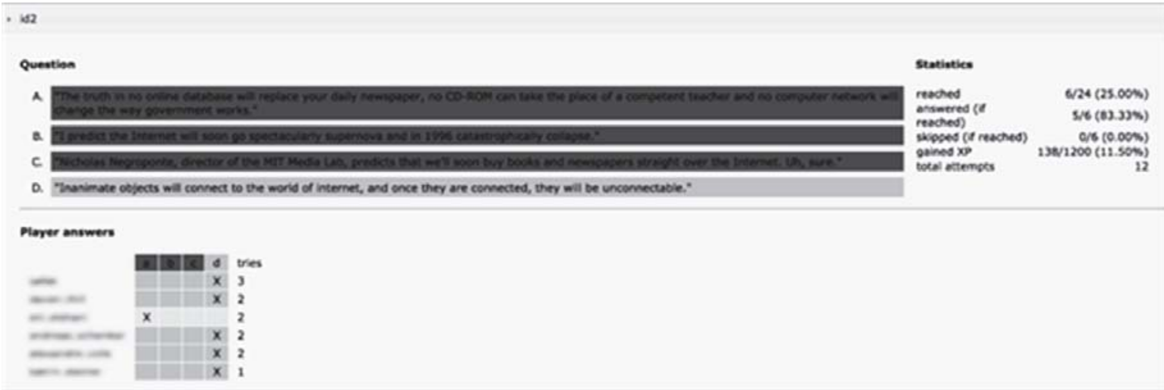

Figure 2: Screenshot of Tourney question-focused data analysis

The question-focused view (Figure 2) offers a detailed overview and information on the questions and their level of difficulty with regard to their solvability. This provides a basic understanding of the users' level of knowledge regarding the given content and helps to identify knowledge gaps. Each special tile (question or content) is represented by a unique identifier in each game stage. These identifiers help to trace the user interactions with the system and cluster them accordingly. Each identifier contains the following information:

- Question and/or Content.
- Answers (correct answer is green, incorrect answer is yellow).
- Statistics (quantitative information):
- *Number of players who reached that special tile.*
- *Number of players who successfully answered the related question.*
- *Number of players who skipped the related question.*
- *Amount of experience points gained in total.*
- *Total attempts of players to answer the question.*

Tracking the attempts of each player for every question and the accuracy of answers represent important elements for the learning progress evaluation. The table in Figure 2 shows the overall attempts and the last registered choice.

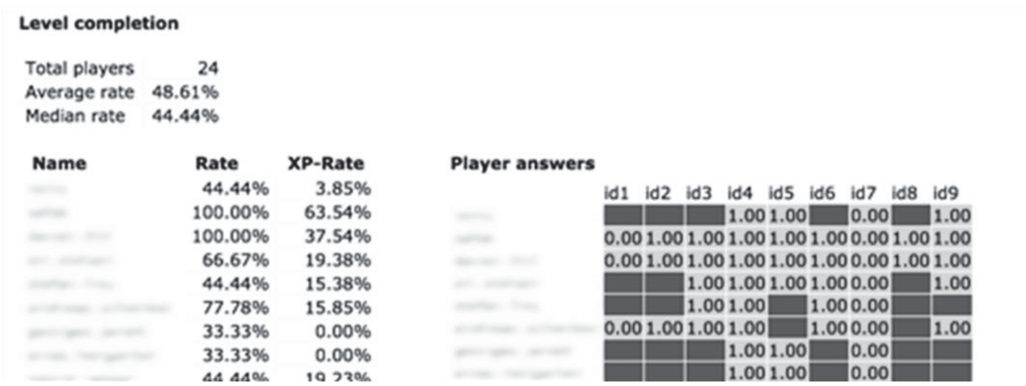

Figure 3: Screenshot of Tourney player-focused data analysis

The player-focused view (Figure 3) offers the possibility to compare the players among each other as well as the player group's overall performance with information on the total amount of players as well as the average and median completion rates. The player-focus view contains the following information:

- Name of the player.
- Rate (The percentage of completion per stage).
- XP-Rate (The percentage of gained experience points (XP) to maximum experience points).
- Player answers (The performance of each player in the game level):
- *Red (); the player has not consumed that tile.*
- *Green (0.00); the player has consumed the tile, and the identified tile is a content tile.*
- *Green (1.00); the player has consumed the tile, and the identified tile is a question tile.*

The player-focused view can offer insightful information on the effectiveness of the game-stage design as well as on the learning performance of a student group.

5. Game stage design

In the current prototype version of Tourney a stage design editor provides different modules and tiles (e.g. content, questions). These tiles can be assigned to the game stage by the game creator (i.e. lecturer) and placed on the editor board. Later on, each module or tile is being enriched by using a text editor. Tourney does not limit the game stage creation in any way. It is possible to create simple, linear paths (Figure 4) as well as labyrinth-like stages (Figure 5) for the players to explore.

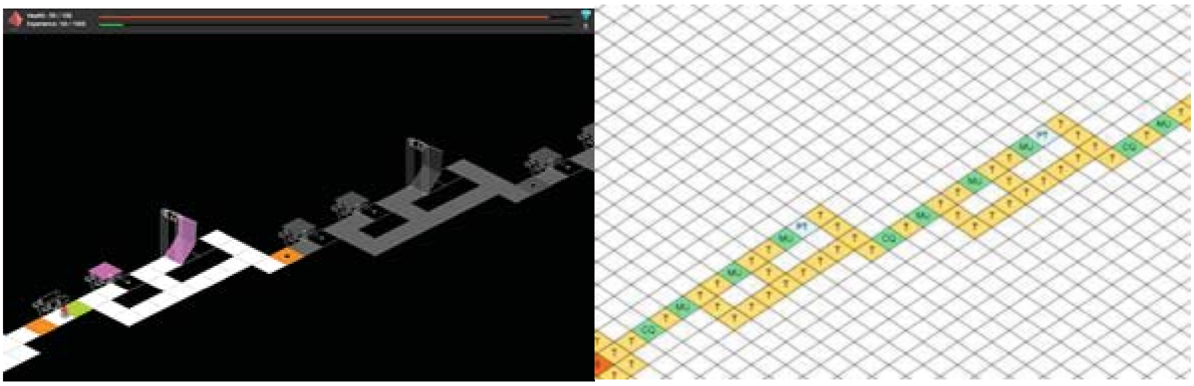

Figure 4: Linear path (game view and editor view)

The editor view (Figure 4) contains a grid map on which the creators can deploy desired tiles by clicking on the desired positions. Each click activates a different type of tile: Normal tile (T), Start tile (S) or Portal tile (P). These three elements must be included in every game stage in order to publish it. Moreover, different special tiles are available, such as multiple choice question (MU), content tile (CQ), free text entry (OQ) and modular question (MO). The stage design, the amount of tiles or the amount of questions are not limited in any way. The research team currently experiments with different types of stage design in order to observe user behavior (player and creator) as well as variations in learning outcomes.

Linear paths in game stage design (Figure 4) are used when the players should achieve predefined learning results by following a path in a linear way. Hence, every question or content is as important as the next one and the content builds up sequentially. Multiple paths in a game stage are used when the creator would like the players to explore a topic and answer questions in no particular order. Figure 6 illustrates this game stage design approach. The questions are positioned in no particular order, although the closer the portal, the harder the questions. The reason for a gradual increase in the complexity and difficulty of the questions is to offer an onboarding strategy for the players and avoid frustration due to hard questions already in the beginning. Additionally, a straight passage to the portal might be implemented (Figure 6) in order to offer players the choice to explore the game stage or not.

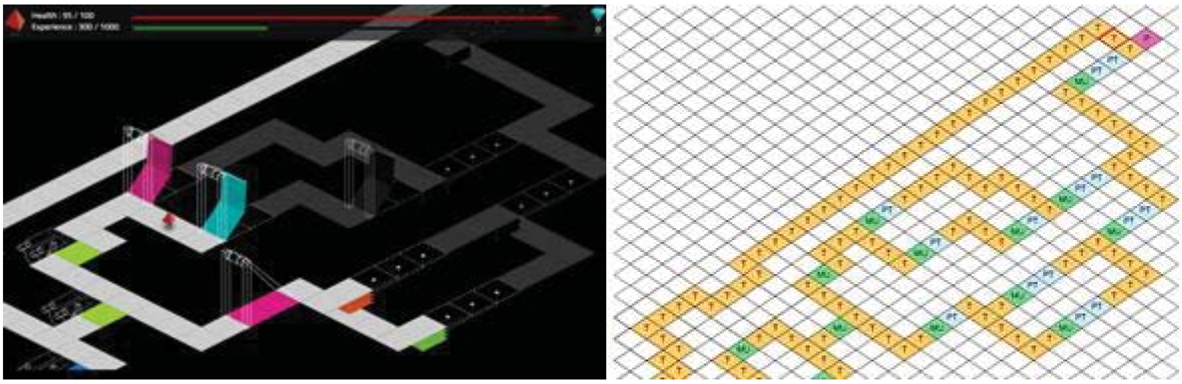

Figure 6: Multiple paths (game view and editor view)

6. The application of Tourney in the context of higher education

In the following, three use cases on the application of the learning game platform Tourney are presented, based on the concept of the CIGF. The analysis of these use cases is based on observations conducted by the research team.

Table 1: Use cases of Tourney

	Game Stage Design	Content	Learning Strategy
Application in Classes	Linear and multiple-path game stages. Size of game stages adjusted to content and time frame of classes. Specific use of integrated media when reasonable to support learning outcome.	Class Relevant	Learning, Content Repetition
Application in Exhibitions	Multiple-path game stages. Medium sized game stages with many integrated videos and pictures as hints and for entertainment.	Common Knowledge	Entertainment, Showcase of concept and functionalities
Application in Workshops	Multiple-path game stages. Small to medium size game stages, integration of many functionalities and media for showcase purposes.	Gamification and Showcase related	Showcase of concept and functionalities, Entertainment

6.1 The use of Tourney in classrooms

In the academic year 2014/15, Tourney has been integrated into the learning design of two different lectures in higher education. To each lecturer the research team proposed different implementation strategies after a collaborative workshop.

The first use case was a lecture titled "Minor in Digital Media". According to the learning design of the class the students were asked to volunteer to prepare a set of questions for the game based on the input of the lectures. It has been communicated that the participation in the game is voluntary and no grade would be given to the players. However, the students who prepared questions were awarded with bonus points. The prepared questions were reviewed by the lecturer and five multiple-path game stages have been designed accordingly. The students' engagement was high in the beginning, but noticeably decreased in the following iterations. When learning games are observed through the lens of game design principles (Schell, 2008), it is important that they are voluntary. However, in this case the students were not challenged enough and eventually preferred to pursue other obligatory tasks during the class, leading them to achieve exam relevant results.

In the second use case for a class titled "Game On" the game stages have been released before the lecture took place. The students were asked to answer a set of questions related to the upcoming lecture. Then, the lecturer analyzed the answers and input of the students and referred to it during the lecture. This use case consisted of four game stages in total. Linear path game stages with free-text questions (OQ) were designed. Twenty students participated. They answered all the questions in all game stages and were engaged throughout the whole semester. The difference in this setting, compared to the first one, was the fact that the lecturer did not give any information about the consequences of the participation, whether it is voluntary or obligatory. According to the lecturer's observations, this had a motivational impact on the students' use of Tourney and led to a broader acceptance and a stronger commitment to use the platform.

6.2 The use of Tourney in exhibitions

The learning game platform Tourney has been used in Swiss marketing trade fairs three times in the years 2014 and 2015 and once in the University Open Day in summer 2014. The user groups were visitors from all different age groups and backgrounds. For these events, a multiple path game stage with general knowledge about Switzerland has been designed and enriched with various media. The game play was guided by the research team, who helped people to understand the platform and presented the use of the system in different scenarios. It was possible to play the levels on different devices. When players completed the game stage, they were free to participate in a lottery to win a gift package from the university. The engagement of the players was very high throughout all events and all users played the complete game stages.

The majority of players answered all of the questions and also participated in the lottery. This use case emphasized the impact of extrinsic motivation in voluntary participation settings. Additionally, it revealed differences in user interaction with the gamified learning tool. While kids intuitively knew how to use the system, older people needed more guidance and introduction throughout the system engagement.

6.3 The use of Tourney in workshops and demos

Tourney has been used in several school internal workshops, presentations and demos as well as for a gamification workshop for a large educational community for new learning technologies at Swiss Higher Education Institutions. In these demos and workshops the goal was to present the learning platform, showcase its functionalities and concept as well as discussing it with experts from education with regard to its implementation in different teaching designs and disciplines.

The majority of educational experts from various disciplines who took part in these workshops were very interested in gamification and innovative learning methods. As a general feedback, the research team observed that there are still impediments to the implementation of technological tools in classes in Swiss higher education, mainly due to the effort and resources it takes to adjust the learning design and content as well as building up own technological competences.

6.4 Use case overview and outcomes

Table 2 summarizes the use cases presented in this chapter. The specific application scenarios, game stage design and target groups are shown as well as identified questions for further research.

Table 2: Use case outcomes

Title	Game Stage Design	Target group	Environment	Remarks	Engagement level	Outlook / Questions
Minor in Digital Media	Multiple Paths	BSc students	Classroom activity	The questions were submitted by volunteering students	Low	Does voluntary game participation decrease engagement?
Game on	Linear Paths	MSc students	Homework assignment	Students were studying on game psychology	High	In what way is student engagement with a gamified tool related to the learning design?

Title	Game Stage Design	Target group	Environment	Remarks	Engagement level	Outlook / Questions
Swiss Quiz	Multiple Paths	General public	Event / Fair	Lottery as extrinsic motivator	High	Does game engagement correlate with extrinsic motivators?
Demo	Multiple Paths	Education Experts	Workshop / Webinar	Bilateral exchange with lecturers, Function Showcase	Medium	How to overcome the obstacles to use gamification in class? How to minimize efforts?

7. Learning outcomes and discussion

According to the observations from the use cases of Tourney the motivation of learners during their engagement with the platform depends a lot on its integration into the class, the teacher's engagement and the communication about the use and the goal of playing the game. With regard to the use cases, the research objective has been to observe the following:

- Which type of stage design is adequate for which content and teaching method?
- Are there benefits from playing the game in the classroom?
- Can voluntary participation in games be effectively integrated into the learning design?
- Are extrinsic motivators, i.e. lottery, helpful to engage people in the use of gamified learning tools?

As an early outcome with regard to the game stage design it has been observed that shorter game stages were more engaging compared to longer game stages. The shorter the stages were, the higher the intrinsic motivation to complete it. Furthermore, it could be observed that a well-wrought choice of game stage design type considering the content and learning goal is beneficial. Multiple-path game stages are slightly preferred compared to linear-path game stages, because of the option to explore. However, in order to validate these observations, larger quantitative experiments are necessary.

The use cases revealed that student engagement and the subjectively experienced benefit from using the game platform are strongly related to the lecturer's approach of integrating game activities into the class as well as the overall learning design. When the lecturers used Tourney to challenge students, engagement was much higher compared to voluntary exercises. Additionally, both lecturers and students have favored using Tourney as a preparation tool instead of as an evaluation tool. Furthermore, extrinsic motivators such as lottery wins or bonus points can increase motivation and engagement with a learning tool. Nonetheless, further research and user interviews are necessary to confirm this outcome.

In the described use cases, two different player behaviors have been observed. The explorer player type (Bartle, 1996) attempted to answer all the questions on the stage before going to the Portal. The achiever player type (Bartle, 1996) instead aimed at the Portal in the shortest possible way. In further iterations of the application of Tourney, the game stage has been modified by implementing a boundary-free road to the portal. This change affected the user behavior and promoted answering more questions, even though there was a straight passage to the Portal. None of the players chose this straight way to the end in this setting. However, the game stage design is highly dependent on the content, class setting and learning goals.

From the different use cases of the learning game platform Tourney we can draw the following conclusions, which are based on user observations and data analysis from the platform:

- When Tourney has been integrated into the class without an extrinsic motivator, the player engagement decreased over time.
- Engaging students to create questions for Tourney has been an effective method to motivate the class and receive positive feedback.
- Publishing a game stage before a lecture as a preparation assignment is more engaging than publishing it after the lecture as a repetition.

- Experiments that last a whole semester need an effective learning design and integration of Tourney into the course curriculum.
- It is very important how the game as well as its benefits and goals are communicated to the students.

The obstacles with regard to the acceptance and implementation of innovative technologies and methods in the educational system remain the biggest overall challenge. Time, costs, technological skills of teachers and an only slowly changing educational system are impediments to a wide use of gamification in education. The academic system still struggles to keep up with technological developments and the changing needs of students with regard to learning design and technology. There is an increasing need to redesign and enhance existing learning environments and designs.

8. Outlook

Based on the above-mentioned use cases of the online learning platform Tourney, more research with a focus on identifying user patterns in the learning data will be conducted. The goal is to analyze, connect and explore the collected data in order to gain new insights on learning and knowledge transfer in the digital context.

Tourney will continue to be an evaluation tool for training and education. During the upcoming academic year, more researchers and lecturers from different institutions will be invited to use the platform and more use cases will be set up and evaluated. Through these first use cases the research team was able to raise several questions about learning games and identify research potential. More data from the application of Tourney will be analyzed and further experiments and interviews will be conducted in order to present qualitative and quantitative results in the near future.

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Making Games With Game Maker: A Computational Thinking Curriculum Case Study

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Abstract: While advances in game-based learning are already transforming educative practices globally, with tech giants like Microsoft, Apple and Google taking notice and investing in educational game initiatives, there is a concurrent and critically important development that focuses on 'game construction' pedagogy as a vehicle for enhancing computational literacy in middle and high school students. Essentially, game construction-based curriculum takes the central question "do children learn from playing games" to the next stage by asking "(what) can children learn from constructing games?" Founded on Seymour Papert's constructionist learning model, and developed over nearly 2 decades, there is compelling evidence that game construction can increase confidence and build capacity towards ongoing computing science involvement and other STEM subjects. Situated at the intersection of 'maker' pedagogies and inquiry-based learning on one hand and game-based learning on the other, this field of educational research is just now more thoroughly being theorized and implemented. There is still debate as to the utility of different software tools for game construction, models of scaffolding knowledge, and evaluation of learning outcomes and knowledge transfer. In this paper, we present a study we conducted in a classroom environment with three groups of grade 6 students (60+ students) using Game Maker to construct their own games. Our study adds to the growing body of literature on school-based game construction through comprehensive empirical methodology and evidence-based guidelines for curriculum design. We also discuss preliminary results related to computational literacy, in addition to a theorization of game construction as an educational tool that directly engages foundational literacy and numeracy and connects to wider STEM-oriented learning objectives.

Keywords: game construction, STEM, computational thinking, technology education, Game Maker, coding

1. In pursuit of "21st century skills"

An ongoing challenge of the 21st century is ensuring everyone has the requisite skills to participate in a digital, knowledge-based economy. This is increasingly difficult under conditions of austerity in both K-12 and higher education, at a time when there is significant need for skilled labour in technology and computing related fields in particular. Despite widespread enthusiasm for "21st century learning," researchers and policy makers around the globe are still trying to articulate exactly what 21st century learning is (Media Awareness Network, 2010), while public education generally is being criticized for not doing it (Francis, 2012; Lynch, 2013). There is, for example, no specific curriculum provision regarding what 21st century learning should entail and how that should inform K-12 schooling, though there is widespread and growing agreement that digital games are somewhere in that landscape (Gee, 2005; Salen, 2007; Squire, 2011). Once an anathema to parents and teachers, digital games are increasingly at the forefront of conversations about ways to address student disengagement (Gee, 2003; Rieber, L. P, 1996; Rupp, Gushta, Mislevy, & Shaffer, D.W., 2010) and to foster 21st century learning and skills (Barab & Dede, 2007; Steinkuehler, 2008; Squire, 2011). That research concentrates on *playing* digital games, whether those are commercially made or made especially for education. Less prominent has been research focused on the *design and development* of games as a means to support critical competencies like creative problem solving, collaboration, and programming skills (Carbonaro, et al., 2010; Denner, 20011; Denner & Wenner, 2007; Papert, 1993). Designing and making digital games, this prior work suggests, can provide an ideal framework for operationalizing 21st century learning: creating digital artifacts entails technical, computational and aesthetic forms of activity whose success depends on bridging between arts and sciences—an intersection increasingly characteristic of the contemporary job market *and* effective participation in social life.

One of the main motivations for bringing *game design and development* into the fold of STEM curriculum planning concerns the need to introduce and familiarize youth, from an earlier age, to the principles of computation, design thinking and procedural logic. The context for this is a growing acknowledgement among educational researchers, computer scientists and teachers that 'computational thinking' and algorithmic logic ought to be considered a kind of 'core literacy' that needs to be incorporated into the school curriculum alongside numeracy, textual literacy and scientific thinking (diSessa, 2000; Wing, 2006). Computational thinking can also be located alongside a range of other competence-based technological 'literacies' discussed in popular education blogs that include 'making' or tech prototyping, fostering of applied 'creativity,' as well as 'design thinking' (REFS). While Papert's work in the 1980s saw the emergence of the first user-oriented *Logo* coding language developed specifically with educational goals in mind, it has only been in the last five to ten years that a plethora of drag-and-drop programming environments for children have become readily and easily available. In that time, too, there have been numerous improvements to the user interface and functionality of these programs, targeting specific age groups and in many cases making tools available on the web as part of online sharing communities of practice[1]. One of the central pedagogical problems with regard to teaching game construction as an entry-level form of computer programming remains defining and operationalizing "computational thinking" as a core curricular concept and identifying how and when to introduce it into the classroom; what tools are best suited and what type of instruction is required to achieve respective cognitive objectives.

2. Definition and 'cognitive objectives' of computational thinking (CT)

Wing (2006) defines CT as "reformulating a seemingly difficult problem into one we know how to solve, perhaps by reduction, embedding, transformation, or simulation." Yadav et al. (2014) define CT as a "mental activity for abstracting problems and formulating solutions that can be automated". Cuny et al. (2010) define it as "the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent". According to Denner, Werner and Ortiz (2011), "algorithmic thinking involves defining a problem, breaking it into smaller yet solvable parts, and identifying the steps for solving the problem." As part of this, students must model the essential characteristics of the problem while suppressing unnecessary details. In the process, "finite sequences of instructions are coded to operationalize the modeled abstractions." From a review of the field in Grover and Pea (2013), the following is a standard list of learning objectives or computational constructs that ought to be covered in some form in instructional designs of entry-level computing:

- Abstractions and pattern generalizations (including models and simulations)
- Systematic processing of information (proceduralization)
- Symbol systems and representations
- Structured problem decomposition (modularizing)
- Iterative, recursive, and parallel thinking
- Conditional logic
- Debugging and systematic error detection

Needless to say, another central problem here is translating these constructs to both affordances of existing game development tools and to specific instructional designs and learning objectives. A number of contemporary studies, for instance, have published extensive breakdowns of tool-specific available actions, modifications, as well as procedural and conditional logic sequences that correspond to top-level computational constructs (Carbonaro, et al., 2010; Denner, 2011; Denner & Wenner, 2007). However, less explicit are the particular pedagogical underpinnings of instructional design by which game construction is introduced and implemented in the classroom within the larger context of mathematics and science (STEM) instruction. Specifically, some of the concerns that need to weigh in include the scaffolding, assessment and transfer of both computational terminology and applied coding skills.

3. Assessment, scaffolding and transfer of conceptual skills

A standard approach in establishing the efficacy of a particular curricular program is using a pre and post-test. Additional study measures include implementing different scaffolding designs (e.g. written materials or direct instruction prior to game construction activity), and exercises that specifically evaluate domain transfer and cross-domain transfer of particular learning content or skill. Depending on the research objectives related to computational thinking instruction (CT) different studies adopt different pre and post-test measures. For instance, given existing evidence that programming performance is related to confidence and attitudes to computing science (CS), there are several instruments that specifically test (using Likert-scale questions) confidence and attitude constructs related to CS (Hoegh & Moskal, 2009; Heersink & Moskal, 2010). Additionally,

[1] Arguably two of the oldest and most widely used drag-and-drop coding environments for early school education are Scratch https://scratch.mit.edu/ and Alice http://www.alice.org/

Seaborn and colleagues (2012) implement a programming-specific pre/post-test that not only tests domain-level questions related to computational terminology, but also evaluate responses to semantically correct programming language (commands written in programming code). A large part of assessment is of course analyzing and evaluating the game artefacts that students create in terms of complexity and the incorporation of specific computational elements. Specifically addressing transfer of computational knowledge, a problem addressed as early as 1988 by Klahr and Carver, Werner, Denner and Campe (2012) propose a de-bugging game as a gamified form of assessment that not only looks at correct solutions, but process of troubleshooting and alternative approaches.

Assessment is also a function of the study design including the overall timeframe of instruction and scaffolding activities. In this sense, and given the practical difficulties of securing ‘classroom time’ as part of regular school curricula, there is quite a lot of variation in the structure and framing, as well as choice of programming environment, in educational research that takes up game construction as a way of teaching computational thinking (CT): e.g. Carbonaro et al. (2010) used ScriptEase, a module-based[2] drag-and-drop game construction program, along with two 6-hr direct instruction workshops at University of Alberta, in addition to 6 more hours at school for kids to finish their games; Denner, Werner and Ortiz (2011) worked with girls in an after-school club setting for over 14 months (1-2hrs a week) designing a series of six different genre games in Stagecast Creator, another module-based drag-and-drop environment; Seaborn et al. (2012) adopted the structure of a ‘design camp’ utilizing Game Maker with high school teams in six modules each lasting several months: their study measured self-efficacy, perception of helpfulness of classroom activities and understanding of computational concepts.

3.1 Teaching coding with game maker: A case study

One of the aims of this study is to interrogate, in addition to the properties and enactment of ‘digital nativity’, the context of game-based learning – that is, how does gameplay experience in kids’ lives relate to their ability to participate and benefit from game construction activities in the classroom? This question is inextricably linked to the larger context of STEM instruction and in that sense this study will contribute to the limited research on game design as a ‘gateway’ to STEM that might, moreover, be a way to effectively *re-fuse* the digital divide which the survey will document and track for the duration of the project. Finally, we set out to explore, beyond simply celebrating the introduction of game construction in the classroom, specific instructional designs that can help and support kids in not only overcoming confidence-related barriers to entry into computing science later in their education, but also support and supplement their grade-specific STEM knowledge through its application in the domain of game-making.

3.2 Study design

This study took place in a very large elementary school (with over 750 children) in Ontario, Canada. Ontario does not currently have any mandatory computer science related curricula at the grade 6 level. We chose to work with Grade 6 students as much of the work done previously (see Carbonaro, et al., 2010; Denner, 2011) suggests that grade 6 and 7 is the point when many students begin to make choices about what courses they will or will not take at the high school level and beyond. In particular, classroom subjects begin to take on a ‘genderized’ character, making girls especially vulnerable to lagging behind their male peers in technologized and computer-related areas. Because there is currently no equivalent curriculum in Ontario, we had to negotiate classroom time with the participating principal and teachers, meaning that in this case we used classroom time that otherwise would have been designated for Language Arts. Our rationale for using class time during Language Arts programming is that we were concentrating on learning a new piece of software that also meant students learning new vocabulary and new concepts related to programming. In the end, we were able to negotiate working with the full grade 6 complement in the school (3 classes, 67 students), replacing their curriculum for a period of 1.5 hours over 6 consecutive days of game design and coding instruction, in addition to a full day of additional curricular programming in a fieldtrip to a university. In total, the participating students had approximately 15 hours using Game Maker and of that, approximately 4-5 hours were direct instruction. Nearly all students worked in pairs to create their games. Peer-based programming instruction has shown in previous studies to be positively correlated with the retention and application of new material (Peppler & Kafai, 2007); in

[2] Typical interactions, settings and game mechanics are pre-programmed in the environment; they are selected as drag-and-drop elements and customized to fit a game-specific situation and purpose.

addition, we wanted to scaffold peer support for students so that they did not just have to rely on the researchers to answer questions and to help move their games along.

3.3 Operationalizing computational constructs

In order to create a usable instructional design for grade-appropriate computational literacy curriculum we had to translate higher-level frameworks of computational thinking such as 'decomposition,' 'parallelism' or 'abstractions and pattern generalization' constructs into operational computer science vocabulary and operations. In particular, amidst increasing critiques of drag-and-drop game design as a form of computational literacy instruction (Duncan, Bell & Tanimoto, 2014) we wanted to depart from bottom-up 'sandbox' environments such as *Scratch* or *Alice* and attempt grade-appropriate instruction directly using code-window semantic programming. Since *Game Maker Studio* provides both drag-and-drop and semantic coding (though, arguably it is skewed towards coding) we landed on using this tool as one of the more versatile products that offer low/mid-entry and high ceiling opportunities for game development; a tool that relates more transparently to computational constructs and the practice of object-oriented programming, and can be adapted for computational instruction at a variety of (upper) grade levels as well. The following table represents our instructional framework across the specific software domain of Game Maker as they link to higher-level computational constructs and vocabulary.

Table 1. Computational instruction framework

CT constructs	Definition / Domain knowledge	Game Maker syntax examples	Computational Vocabulary
Variables	Containers for storing values so that values can be used and modified in other parts of the program	direction = 180; speed = 4;	Variable, value, object, instantiation, syntax, rate of movement, direction
Operations	Mathematical operations with variables or other parts of the program that cause game state changes	score = score + 1; x = x – 7;	Mathematical operations, Cartesian (x/y) coordinates, syntax
Functions	Built-in computational objects, modifiable constructs that cause specific game actions and state changes	instance_destroy(); move_bounce_solid(false);	Function, Boolean logic (true/false), syntax, attributes, parameters, nested operations, placeholder

Conditionals	Statements that evaluate a game state and cause other game actions, operations, variable changes etc. to take place	if place_meeting (x, y + 1)
		{
		gravity = 0.01;
		}
		else
		{
		gravity = 0;
		}
			Boolean evaluation (if/then/else), conditional logic, branching and nesting, truth value, queries

3.4 Instructional design: Scaffolding and facilitation

In previous iterations of this type of study –game design camps with grade school students – we typically relied on heavy facilitation and one-on-one work with students or project peer groups to help students complete a functional and polished version of their game idea (see Fisher & Jenson, Forthcoming). We still used *Game Maker*, however our curriculum was based on drag-and-drop commands and the instructional format was after-school clubs rather than classroom-based instruction. The system of instruction we used formerly comprised of one extensive follow-along tutorial of Game Maker's sandbox game the *Brick Breaker*[3] followed by unstructured game design time for kids to work on their own game ideas. For this iteration of research, particularly given that it was based out of a classroom space, during school time, we scaffolded coding instruction with a series of direct follow-along lessons where kids learn new vocabulary and practice applying new programming constructs in appropriate chunks of material. The rest of each session kids got to work on their own game, adapting and modifying elements that were just covered in their own design. Key to our curriculum design in this study was the pacing of instruction and material and the incremental introduction of computational concepts: i.e. we first introduced the concept and application of variables; then the role and syntax of operations; followed by the

[3] http://sandbox.yoyogames.com/games/120704

concept and use of functions (including in-depth self-help strategies using Game Maker's reference guide for game programming); finally we introduced the syntax and function of conditional statements, all the while reinforcing previously learned vocabulary, as well as reiterating the logic and relationship between game events and game actions (input and output).

As part of our curriculum we also built in the option for kids to look into several developed example games and copy and adapt code from them as a kind of 'ecological' approach to coding instruction, given that copying and adapting code is foundational to good programming habits (Duncan, Bell & Tanimoto, 2014). Our vision for facilitation in this much more structured and scaffolded game construction curriculum was of research facilitators assisting with software/interface issues (since Game Maker has a bit of a learning curve) and helping to guide kids in design and programmatic challenges through case-by-case directed instruction, rather than dictating or writing code for them. To enable this model of self-directed learning we actually enforced a "Ask 3 before you ask Me" rule where kids had to look up a question they had in the Game Maker help or ask a peer before they turned to a research facilitator.

3.5 Data collection

Prior to the study, every participant was given a media literacy and attitudes questionnaire, as well as a pre-test designed to evaluate students' existing knowledge of computer science concepts such as what variables, operations and functions are. Following the study, a post-test was administered that was identical to the pre-test and a short questionnaire that repeated the same attitudinal questions from the medial literacy and attitudes questionnaire was completed in order to determine what if any attitudinal changes might have occurred. In addition, daily field notes were taken by at least two researchers who were on hand for the duration of the study, as well as short video clips and photos as students worked on their games. To capture the progress that participants were making daily as well as to gauge how much and what type of help participants were receiving from researchers, we used Chronolapse, a software that records an image of the computer's screen along with a webcam image every 15 seconds. In total, we generated 256 Chronolapse videos of approximately 1.5 hr duration and recorded 36 qualitative fieldnotes of each classroom session day.

4. Results and discussion

Given that the study and data collection are still ongoing, in this paper we report some preliminary results and set up some areas of critical discussion related to the issue raised earlier. We discuss some preliminary correlations as anecdotal evidence that will be supported in the next iteration of reporting with a statistical analysis. Overall, the classroom-based instructional model seemed to function well for grade 6 students working in pairs, and they were able to create playable complete games using Game Maker within the 6 classroom sessions + 1 extended university-based field trip. Not only did students design and code their games with minimal facilitation, but their content knowledge of basic computational terminology, as well as Game Maker domain knowledge improved from an average of 6.7 to an average of 9.3 (out of 16). In the following sub-sections we discuss additional preliminary data organized around several critical areas: 1) assumptions 'digital nativity' related to both playing games and pre-existing computer-based (and computational) knowledge; 2) the relationship between gender, confidence, and attitudes towards computer programming instruction; and 3) preliminary results about gender differences in computer programming performance in the context of game construction. Finally we comment on some initial impressions related to our study design, facilitation and classroom-based context.

4.1 Digital nativity: Surveying media use and playing games

In terms of general media use (based off the questionnaire), boys and girls are similarly likely to use social media, and almost everyone reported YouTube as one of their top websites/social media sites to visit at home, closely followed by Facebook and Instagram. Girls are slightly more likely to report that they use online communication tools such as Skype or FaceTime, as well as more likely than boys to frequent the micro-blogging platform Tumblr. While most kids reported regularly playing videogames, boys are much more likely to play online multiplayer and high-end console games, and girls a bit more likely to play puzzle or role-playing games on the Wii platform, as well as have access to tablets and play mobile games. Some of these gender differences in access to and use of computers and gaming consoles likely speaks to cultural advertising that targets boys for high-end consoles such as XBOX and PlayStation, while establishing a wide audience for 'educational' tools such as the Wii Series or the iPad[4]. Of the kids who reported that they did not own gaming platforms or played games, the majority were girls. These nuanced gender differences were also noted by researchers in the classroom during instruction, with boys much more likely to raise their hand to answer questions related to gaming and computers, and girls much more likely to volunteer answering questions about mathematics, language and other STEM content that figured into computational concepts. Potentially related to these statistics of media and video game use, girls indeed had a slightly lower average score on the computational literacy pre-test compared to boys, and boys' post-test scores improved significantly more than girls' scores (see Figure 2). That said, girls tended to have more consistent average scores, whereas boys' competence was split between those who had very little knowledge and those who had extensive prior experience with computing and gaming.

Figure 1: Classroom set up and kids working on game design and game programming

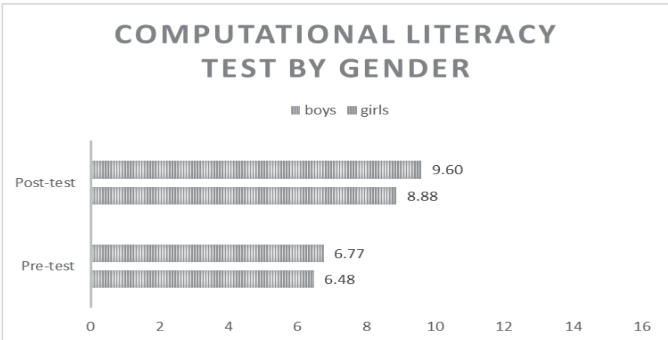

Figure 2: Computational literacy pre and post-test results by gender

What is interesting here in terms of the oft-assumed relationship between 'digital nativity' and aptitude for computer science, is that reported frequent gameplay activity did not correlate with either a high score on the computational knowledge pre-test, or with an overall high confidence about using computers and learning programming. One exception was, notably, that playing Minecraft did indeed correlate with higher pre-test scores and overall higher confidence about using/learning about computers. Not playing games (at all) on the other hand correlated with lower confidence about using and learning about computers and lower pre-test scores. This context both confirms and questions some of the game-based learning assumptions pointed out in past work – namely, that playing video games creates base computational knowledge and confidence about technical computer skills. Our work suggests that playing video games is one important ingredient to creating the conditions for computer programming instruction and computational literacy, but there are more issues at play here. For instance, when we look at performance on the computational knowledge pre-test, on average, kids who had higher scores actually reported less confidence about their ability to learn new computer programs, computational concepts, and troubleshoot computer programs. Conversely, kids who displayed some of the lowest pre-test scores reported some of the highest confidence about working with computers and being able to use and learn new computer programs. This finding is of critical pedagogical importance because it suggests that procedural 'content' knowledge about computer programming does not necessarily translate into confidence or ability to contend with new computational instruction. So there are more issues there that we need to understand better, specifically around kids using computers and engaging in gaming and social media including what, if and how that supports "learning."

[4] http://www.edutopia.org/blog/ipad-teaching-learning-apps-ben-johnson

4.2 Gender-related issues in computer programming instruction

To develop and implement a school-wide computational literacy program based in game construction, it is necessary to first examine and understand some of the underlying context of STEM education at the grade 6 level, as well as some of the persistent gender differences in confidence and preparedness in relation to computer work in general. Confidence and attitudes has already been linked in numerous studies (Carbonaro et al. 2010) to actual classroom performance and the ability to learn computer programming, as well as the motivation to continue on this educational track. Given this, an important part of the pre-study questionnaire was gauging self-reported confidence around using computers and learning computer programming, as well as gendered attitudes towards computational literacy. Results we've collected so far suggest that while both genders think the other gender is worse at computer programming, boys were much more likely to assess girls' computer skills as low, whereas girls had mixed evaluations of boys' capabilities with programming. This trend translates into self-reported attitudes and confidence with regard to computer skills in general and one's capacity to learn programming (see Figure 3). Girls consistently scored lower in confidence levels than boys, and in particular, they scored significantly lower on confidence in their abilities to troubleshoot computer programs as well as general self-confidence when it comes to computer programming.

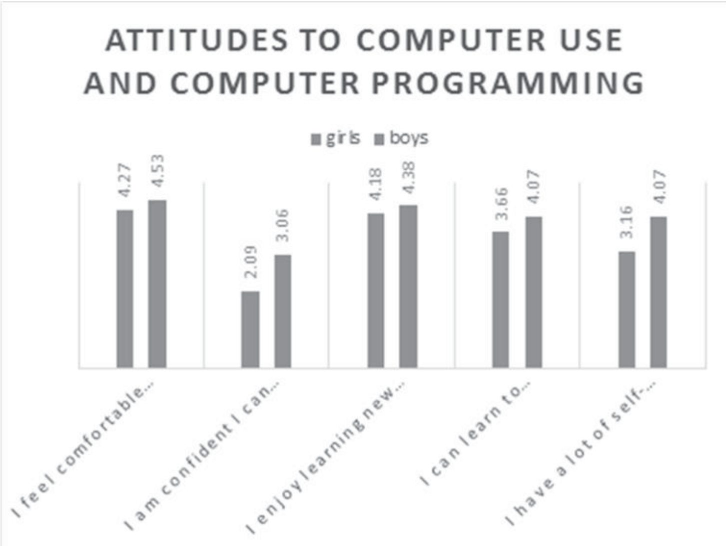

Figure 3: Attitudes to computer use and computer programming by gender

Some of the positive findings around attitudes to computer science were that neither girls nor boys reported any social stigma for 'being good with computers' and on the whole everyone gave positive answers to the idea of studying computer programming at school, being interested in computer programs, pursuing computer science further, and having a future career that includes computer work and coding. When asked what they thought computer programming would be good to teach at school, girls were slightly more likely to list 'collaborating with others' and 'solving problems'. Most kids listed 'making learning fun' and 'learning specific content' but very few ticked 'learning about logic', which reveals a gap in terms of what students understand computer programming instruction to be in a school setting.

4.3 Study design and facilitation: Lessons learned

While we have indicated in another section above that the curriculum we developed included direct instruction for the parts of the curriculum that included procedural coding using the coding "window" that is available in Game Maker (see Figure 1, left side), we did have to spend quite a bit of time "tweaking" our curriculum as we also were developing it. In this section we will briefly detail three primary lessons that we learned in this pilot study. First: we found that it was necessary to begin each session with a piece of direct instruction that highlighted the programming concepts that we wanted students to practice in their own games. Once that direct instruction was accomplished, we turned the rest of the time over to them to work on their own games, supported by the researchers and a team of facilitators that were trained in Game Maker. Interestingly, we also had to manage the facilitators' expectations for providing help, as they sometimes provided help by directly fixing code and/or by providing code that the students could not yet know in order to make a game work. Second, we found that we had to do quite a lot of managing of student expectations for the games they wanted to create; all too often they wanted to make games that exceeded their abilities and were not able to re-design their games with their limited abilities in mind. While this is not necessarily a surprising outcome, it was surprising to us how many participants were unfamiliar with just how much is involved in game design, and how demanding their designs were from a programming standpoint. This points back to the lack of any formal curriculum in Ontario with regards to computer programming, and also to the necessity for that at much earlier grade levels. Finally, as much as we wanted to create an 'open design' experience for participants, in hindsight, the fact that we did not assign a game theme or genre, nor did we insist that they replicate the game we used to demonstrate core concepts, meant that (for some) the task was overwhelmingly vague. For those who were overwhelmed, we often had them recreate the game that we used as demonstration and that meant that they could get on with the task, and for some change/hack the game we were using in an interesting way.

5. In conclusion

This paper presents just some of the core findings from a pilot study that made use of a free, commercially available, game design program (Game Maker) to introduce and allow kids to practice applying key computational thinking constructs such as variables, operations, functions, and conditionals. Overall, participants were enthusastic users of the tool, and did not struggle in the time we spent with them (for the most part) to stay on task or stay interested in their own game development. While we have not reported here on the affective engagement of our participants, it is, in fact a highly relevant outcome of the study, and one that we will elaborate on in future papers, as we also had an opportunity to hear from parents of participating students who reported that their children were keen to continue working on their games outside of classroom time. Based on our preliminary discussion of the data above, there are three primary conclusions that are worth emphasizing. First, as others have pointed out, claims that today's students are defacto 'digitally native' is not the case for all students, nor does it indicate that students have familiarity or even facility with basic computer programming skills and competencies. Second, there are still gender differences in attitude and confidence with computers that in an instructional study such as this can and did affect performance on programming related tasks, not only on the post-test, but also in our many observations of girls during the time we spent with them. In general, they were less willing to participate in public displays of knowledge (like answering questions to the whole group) and were more likely than their male counterparts to 'disavow' their skills with speech acts such as: "I always break the computer" and "I am not good at computers". Such differences in attidues, we show can and do affect performance. Finally, our model of a structured curriculum that combines applied work with direct follow-along instruction is encouraging and we hope replicable in eventually, a school district-wide instructional programme. In conclusion, this preliminary analysis has shown that using a commericallly available game design software that permits a variety of scalable programming actions in the process of coding and testing a game, is not only a viable way of introducing a middle-school demographic to computational literacy but is one other means for fostering and supporting STEM related competencies, vocabularies and skills.

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Computerized Simulations of the Israeli-Palestinian Conflict, Knowledge Acquisition and Attitude Change

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Abstract: This paper presents two cross-cultural experimental studies comparing the effects of PeaceMaker (PM) and Global Conflicts (GC) on knowledge acquisition and attitude change regarding the Israeli-Palestinian conflict. PM and GC are role-playing computerized simulations of this conflict, but there are a few key differences between them which may impact their learning outcomes. First, GC provides a more personal and human perspective on the conflict than PM. Second, GC is a more immersive game environment than PM. Finally, PM is an interactive and multimodal game environment compared to GC. 248 undergraduate students from Turkey, Israel, Palestine and the US participated in the two studies. They were required to fill in questionnaires measuring knowledge on the Israeli-Palestinian situation and attitudes regarding the conflict before and after playing the game. Results suggested that participants playing PM acquired more knowledge about the conflict than those playing GC. Second, participants playing GC became more impartial toward the Gaza operation in 2012, unlike those playing PM. Finally, participants playing GC became more impartial regarding long lasting historical issues in the conflict (i.e., Jerusalem, settlements, refugees, water, borders and security), unlike those playing PM. The results show that computerized simulations are useful as part of peace education training, but the game characteristics may be crucial in determining whether the players gain the perspective of both sides or not.

Keywords: PeaceMaker, global conflicts, Israeli-Palestinian conflict, peace education, computerized simulations, serious games

1. Introduction

Intractable inter-group conflicts are highly resistant to resolution, involve well-entrenched hostile perceptions of the out-group, drag on for an extended period of time, and are prone to escalation over and over again (Bar-Tal, 2013; Coleman 2000; Kriesberg, Northrup and Thorson, 1989). In such conflicts, hostile attitudes and images of the enemy are passed on from one generation to the next with the learning of the conflict narratives embedded in various socialization agents. Conflict narratives often promote an ethnocentric view of past or present events and people on the two sides hardly communicate with each other directly (Bar-Tal, 1997).

Peace education is one of the key theories of change and practical tools that have been developed by conflict resolution and political psychology disciplines to change attitudes and reframe conflict narratives in order to resolve conflicts (Salomon, 2008; Salomon and Cairns, 2009). Peace education often has the goals of reducing inter-group prejudice and negative stereotyping, promoting inter-group empathy and understanding, building trust, and creating awareness about the root causes of the conflict and about non-violence. Promoting and facilitating inter-group contact and educating the participants on various aspects of conflicts and peace-building are among the common activities used in peace education initiatives in order to attain these goals (Salomon, 2008).

The prevalence of the Internet in the last two decades has added a new dimension to peace education activities, and provided a new set of tools intended to reduce inter-group conflict. Web based role-playing games, computer chat rooms and social media began to be used as another potential venue to educate members of adversarial groups about one another. These new tools can be an alternative medium to accomplish the goals of peace education, as articulated by Salomon (2008). With the help of computer mediated games and forums it may be that people can learn to legitimate the other's collective narrative and see events through both lenses; critically examine their in-group's contribution to the conflict and challenge their perception of sole victimhood; and perhaps develop empathy in order to appreciate the other's pain and loss and generate mutual humanization.

The present studies examined the use and effectiveness of technology as a pedagogical tool in educating about conflicts and peace building. There is very little research on this question, and very few assessments have involved cross-cultural experimental studies (e.g., Bhappu et al, 2009; Ebner, 2008; Matz and Ebner, 2010). Two cross-cultural experiments were conducted using PeaceMaker (PM) and Global Conflicts (GC) which are role-playing computerized simulations of the Israeli-Palestinian conflict (Buch and Egenfeldt-Nielsen, 2007; Burak, Keylor and Sweeney, 2005). The studies were specifically interested in the following questions: Will there be differences in knowledge acquisition between GC and PM? Will there be differences in attitude change between GC and PM? Knowledge acquisition about the conflict is an important requirement for attitude change regarding key issues in the situation (Maoz, 2011; Maoz and McCauley, 2005; Suleiman, 2004). Attitude change is considered as one of the most important outcomes in peace building activities as it is often regarded as the pre-requisite of developing empathy toward the "other" (Bar-Tal, 1997; 2013; Maoz and McCauley, 2005; Suleiman, 2004).

Previous studies have already indicated the effectiveness of GC and PM as a pedagogical tool in teaching conflict assessment and resolution (e.g., Buch and Egenfeldt-Nielsen, 2007; Gonzalez, Saner and Eisenberg, 2013; Raphael et al, 2012), but they used self-reports (e.g., How much do you think you learned from the game?) and game score as measures of learning outcomes, while the present studies use measures of background knowledge and attitude change. Furthermore, the present studies add a cross-cultural assessment to the two games by having students from different cultural and political backgrounds. The two studies were conducted with Israeli-Jewish, Palestinian, American, and Turkish undergraduate students, assessing the effectiveness of the games by differentiating between direct parties (i.e., Israeli-Jews and Palestinians) to the conflict and secondary/third parties (i.e., Turks and Americans).

The present studies are important in that they are the first to provide empirical evidence for the effectiveness of GC compared to PM in motivating learning and teaching skills required for peace building. There are a few key differences between the two games which may impact their learning outcomes. First, recent studies have indicated that role-playing computer games that involve winning such as PM (unlike GC) enhance positive learning outcomes, because they are highly motivating, capture the learners' attention and engage the players in the learning activity (e.g., Bogost, 2007; Peng, Lee and Heeter, 2010). Second, PM focuses on the perspectives of the Israeli Prime Minister and the Palestinian President on the Middle Eastern situation, while GC focuses on the hardships experienced by both Israeli soldiers and Palestinian people in the conflict. The latter may provide a more personal and human perspective on the situation than the former. Therefore, young people like those participating in the present studies may find it easier to identify and empathize with, resulting in more positive effects on attitude change (Bar-Tal, Halpern and Pliskin, in press; Schori-Eyal, Halperin and Bar-Tal, in press). Third, GC may be a more immersive game environment than PM. The immersion effect creates an environment in which the players submerge themselves and progressively increase their attention and concentration in this environment, resulting in more positive effects on attitude change (Raphael et al, 2012; Yan and Cordry, 2011). Finally, in PM (unlike GC) the player can draw upon information about relevant events appearing on the screen in text, videos and pictures from real-time news broadcasts and by clicking on maps, cities and polls, enabling her to formulate an informed game behaviour (Burak et al, 2005). Empirical evidence has already indicated that the combination of the two dimensions - interactivity and multimodality – is very effective in influencing people's levels of knowledge about socio-political issues (e.g., Bogost, 2007; Gee, 2008).

1.1 The PeaceMaker game

In PM a player can assume the role of either the Israeli Prime Minister or the Palestinian President and engage in a series of decisions with the aim of satisfying constituents on both sides of the conflict. PM can be played in English, Hebrew, and Arabic, on calm, tense, or violent conflict levels, differing in the frequency of events that appear on the screen and are beyond the player's control. In order to deal with these events, a player can select actions pertaining to three main categories: security, political and construction, each branching into a variety of sub-categories such as checkpoints and speeches. In order to resolve the conflict in the game, scores for both Israeli and Palestinian sides must reach 100 points each. If either score drops below -50 the player loses the game.

1.2 The Global Conflicts game

GC consists of several different conflictual scenarios, each putting the player in a different conflictual context and requiring the deployment of different skills. This study focuses on the one about the Israeli-Palestinian conflict, illustrating the tensions between the two sides in a checkpoint scenario. The player is represented by an avatar of a Western reporter who arrives in Jerusalem. Her task is to write for one of the following newspapers: Israeli, Palestinian, or Western. The player is expected to produce a news report geared to the audience of one of these newspapers based on the interviews she conducts with various Israeli and Palestinian characters at the checkpoint in the Palestinian territories. The player is challenged to keep her work objective while gathering important information to be used in the news report. The student has to form an opinion based upon her own actions and after meeting characters that represent different attitudes to the conflict, despite the fact that she writes for a specific newspaper.

2. Research questions

RQ1. Will there be differences in knowledge acquisition between GC and PM?
RQ2. Will there be differences in attitude change between GC and PM?

3. Methodology

3.1 Participants

148 undergraduate students of political science participated in the PM study, including 38 Turkish students from Bilkent University, 50 Israeli-Jewish students from Tel Aviv University, 30 American students from Wichita State University and 30 Palestinian students from Al-Quds University. The four groups did not differ in terms of gender (X^2 (3, 144) =.40, *p*=.58). Israeli students of Jewish origin were older (*M* = 25.12 *SD* =1.32) than American students (*M* = 22.7 *SD* =2.39), Turkish students (*M* = 21.42 *SD* =1.59) and Palestinian students (*M* = 21.1 *SD* =1.17), *F*(3, 144) =44.57, *p*=.0001. In general, Israeli students are older than the latter three groups due to service of 3-4 years in the army before studying at university.

140 undergraduate students of communication and political science participated in the GC study, including 30 Turkish students from Bilkent University, 40 Israeli-Jewish students from Tel Aviv University, 40 American students from Wichita State University and 30 Palestinian students from Al-Quds University. The four groups did not differ in terms of gender (X^2 (3, 136) =.37, *p*=.76). Israeli students of Jewish origin were older (*M* = 25.12 *SD* =1.32) than American students (*M* = 22.04 *SD* =4.45), Turkish students (*M* = 22.02 *SD* =1.94) and Palestinian students (*M* = 21.17 *SD* =1.44), *F*(3, 163) =44.57, *p*=.0001.

The studies also included 30 Israeli-Jewish students of communication from Tel Aviv University who did not play the games (control group) (11 of whom were males), and 30 Palestinian students of political science from Al-Quds University who did not play them (control group) (11 of whom were males).

3.2 Design and procedure

The data on the PM study were collected in Spring 2013 and the data on the GC study were collected in Spring/Summer 2013. No major event happened between the data collection of the two studies that could bias the results.

Both studies were part of classes in political science and conflict resolution, took up to three hours and included four parts. First, participants were introduced to the game and played a short demo. Second, they filled in a short questionnaire. Third, participants played the game. In the PM study, they played the Israeli role and the Palestinian role in random order at the calm conflict level (i.e., low frequency of inciting incidents), because the study examined learning outcomes rather than game performance, which focuses on how well the player deals with high frequencies of inciting incidents. In the GC study, the participants were assigned to represent the Israeli or the Palestinian newspaper. The GC game provides both Israeli and Palestinian perspectives on the conflict no matter which role was assumed, while the PM game provides either the Israeli or the Palestinian perspective depending on the role played. Therefore, participants played both Israeli and Palestinian roles in the PM study in random order and either the Israeli or the Palestinian role in the GC study. Finally, after playing the game, the participants again filled in a short questionnaire. The questionnaires used before and after playing the game were almost identical in content with the exception of a few additional questions in the post-questionnaire deliberating participants' experience with the game.

The control condition was conducted in Spring/Summer 2013 as part of classes dealing with digital natives and news consumption (not related to the conflict). It included three parts and took up to three hours. First, participants filled in a short questionnaire. Then they were given a lecture about digital natives and news consumption. Finally, they again filled in a short questionnaire. The two questionnaires were similar to those used in the experimental condition (besides questions deliberating participants' experience with the game).

3.3 Measures

For measuring knowledge about the Israeli-Palestinian conflict, students were asked a battery of 24 open-ended and closed-ended knowledge questions on various political and historical aspects of the Israeli-Palestinian conflict varying in degrees of difficulty, such as: "Name the parties to the 1993 Oslo agreement"; "What is the Green line?"; "Who is covered in the Right of Return?"; and "What is the meaning of the Nakba Day?". The study considered the number of correct answers in the two questionnaires.

The studies used two measures for assessing attitudes in the conflict. The first one examined ‘how right is each side’ on key issues in the conflict, including water, refugees, borders, settlements, Jerusalem, and security, using the following scale: 1. Palestinians are absolutely right, 2. Palestinians are somewhat right, 3. Both sides are equally right, 4. Israelis are somewhat right, and 5. Israelis are absolutely right. After conducting a factor analysis, the average of answers given on the six key issues was used as a measure of attitude change about key issues in the conflict before and after playing the game.

The second measure examined attitudes toward the Gaza operation by asking ‘how right is each side’ on the Gaza operation using the abovementioned scale. The studies referred to the Operation Pillar of Cloud in November 2012. This measure was used, because the Gaza operation was a recent event at the time when the study was conducted, receiving extensive media coverage and public debate, as opposed to the abovementioned measure focusing on long lasting historical issues in the conflict.

3.4 Statistical procedures

To test the research questions, a three-way ANOVA was conducted with game type (GC or PM) and nationality (Israeli, Palestinian, American or Turkish) as between-subjects factors and time (pre- and post-game) as a within-subjects factor. This procedure investigated the effect of playing the GC or PM games on knowledge acquisition and attitude change at two separate time points: pre- and post- game intervention. The important point with this study design is that the same participants are measured twice on the same dependent variable. Therefore, this test detects any overall differences between related means. The paper only presents results concerning the effect of game type on knowledge acquisition and attitude change due to length limitations.

4. Results

4.1 Knowledge acquisition: Global Conflicts vs. PeaceMaker

The interaction between time and game type was significant ($F(1,246)=20.25$, $p<.0001$, $\eta^2= .18$). Participants who played PM acquired more knowledge after playing the game (M=11.39 SD=6.15 M=14.94 SD=5.89) than those who played GC (M=10.17 SD=6.22 M=12.36 SD=5.39) (Table 1).

No significant change was found in knowledge acquisition regarding the Israeli-Palestinian conflict in the control group of Israeli-Jewish students and of Palestinian students.

4.2 Attitudes toward key issues in the Israeli-Palestinian conflict: Global Conflicts vs. PeaceMaker

The interaction between time and game type was significant ($F(1,246)=32.13$, $p<.0001$, $\eta^2= .26$). Participants who played GC got closer to thinking that both Israelis and Palestinians were equally right regarding key issues in the conflict after playing the game (M=2.28 SD=1.18 M=3.08 SD=1.04), unlike those who played PM (M=2.48 SD=.79 M=2.65 SD=.81) (Table 1).

No significant change was found in attitudes regarding key issues in the conflict in the control group of Israeli-Jewish students and of Palestinian students.

4.3 Attitudes toward the Gaza Operation: Global Conflicts vs. PeaceMaker

The interaction between time and game type was significant ($F(1,246)=15.31$, $p<.0001$, $\eta^2= .14$). Participants who played GC got closer to thinking that both Israelis and Palestinians were equally right regarding the Gaza operation after playing the game (M=2.21 SD=1.53 M=3.11 SD=1.33), unlike those who played PM (M=2.52 SD=1.34 M=2.79 SD=1.29)(Table 1).

No significant change was found in attitudes regarding the Gaza operation in the control group of Israeli-Jewish students and of Palestinian students.

Table 1: PeaceMaker vs. Global Conflicts: Learning outcomes

	PeaceMaker		Global Conflicts	
	Before playing the game	After playing the game	Before playing the game	After playing the game
	M(SD)	M(SD)	M(SD)	M(SD)
Knowledge Acquisition	11.34(6.15)*	14.94(5.89)*	10.17(6.22)*	12.36(5.39)*
Attitudes toward key issues In the Israeli-Palestinian conflict	2.48(0.79)*	2.65(0.81)*	2.28(1.18)*	3.08(1.04)*
Attitudes toward the Gaza operation in 2012	2.52(1.34)*	2.79(1.29)*	2.21(1.53)*	3.11(1.33)*

*P<.0001

5. Discussion and conclusions

The studies aim at assessing the impact of using technology in motivating learning skills required for peace building. The results are promising, albeit requiring further assessment. First, participants who played PM acquired more knowledge about the Israeli-Palestinian conflict than those who played GC. Second, participants playing GC acquired a more impartial perspective toward the Gaza operation in 2012, unlike those playing PM. Finally, participants playing the GC game shifted from ethnocentric attitudes towards a more impartial attitude regarding long lasting historical issues in the conflict, unlike those playing the PM game.

A few explanations can be suggested for the different learning outcomes of the two games which require further research in the future. First, in contrast to GC, PM is a game that involves winning, which can further motivate the players to acquire knowledge, including those who at first are not particularly interested in the subject matter (e.g., Lepper and Henderlong, 2000; Lieberman, 2006). Second, PM focuses on two dimensions – interactivity (i.e., by clicking on maps, cities and polls) and multimodality (i.e., by presenting information about relevant events in text, videos and pictures). Previous research suggested that these dimensions are more effective than other presentation modes in influencing people's levels of knowledge about socio-political issues (e.g., Bogost, 2007; Gee, 2008). Third, GC provides a more personal and human perspective on the Israeli-Palestinian situation than PM. Therefore, young players may find it easier to identify and empathize with, resulting in more positive impact on attitude change. Finally, GC may be a more immersive game environment than PM, resulting in more positive effects on attitude change (Raphael et al, 2012; Yan and Cordry, 2011).

Another possible explanation can be suggested for the different learning outcomes of the two games with regard to attitude change. Participants playing PM may have stronger attitudes about the conflict than those playing GC. The studies were conducted shortly after the Gaza operation in 2012, an event which received extensive media attention and public debate. The data on participants in the GC study were collected *after* the data on participants in the PM study. Therefore, the latter may have more salient attitudes about the conflict than the former, and research on attitude strength suggests that salient attitudes are more resistant to change and lead to selective cognitive processing (e.g., Eagly and Chaiken 1998; Kelman, 1997; Pettigrew, 1998). Furthermore, when one's attitude is linked to one's 'self' concept or value system, the attitude is more resilient to change (e.g., Pomerantz, Chaiken and Tordesillas, 1995). In the future, it would be interesting to compare the short-term and long-term impact of game interventions on attitudes and behaviours, particularly since the number of studies on long-term effects of peace workshops in protracted conflicts like the Israeli-Palestinian situation is extremely limited (e.g., Malhotra and Liyanage, 2005; Maoz and Bar-One, 2002; Rosen and Salomon, 2011).

The results comparing the effectiveness of GC and PM are promising in terms of showing that computer games can be used as part of peace education training. They indicate that these games are useful not only in teaching a more complex view of the conflict to the parties, but also in engendering attitude change, especially in the form of taking a more balanced perspective and being able to look at the conflict through both lenses. However, it is also important to note the different results obtained from the two games. The game characteristics may be crucial in determining whether the players gain the perspective of both sides or not. Further research is required to understand how PM and GC achieve their learning effects, by singling out different dimensions of the two games to provide a more in-depth and comparative analysis of their impact.

Previous studies have already shown that Israeli and Palestinian young people know almost nothing about what transpires on the other side of the Israeli-Palestinian divide, except for the limited and violent images constructed by the media and daily incidents (e.g., Wolfsfeld, Frosh and Awabdy, 2008). Moreover, since these young people have never actually experienced a state of peace they may not regard it as a significant value for which a price should be paid. Therefore, the opportunity for young Israeli and Palestinian people to learn about and perhaps understand the "other" party, even if through computerized simulations like GC and PM, is an issue of great importance in any process of reconciliation in the Middle East and an essential requirement for obtaining public support and legitimacy for any peace initiative.

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Towards an Efficient Mobile Learning Games Design Model

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Abstract: Classrooms are increasingly equipped with information and communication technology and especially interactive mobile devices. However, the latest studies show that their use by teachers is still very limited because of a lack of resources and applications adapted to an educational use. Indeed, there seems to be a shortage of mobile learning practitioners due to the time required for these tools' apprehension. Likewise, studies show real needs to expand the variety of applications, resources and activities available on these mobile devices, in order to make them more suited to the teachers' pedagogic objectives. Concurrently, new ways of using mobile devices for education are arising. Among those directions of use, research conducted on Mobile Learning Games (MLGs) seems particularly promising. In this paper, we propose to identify several MLGs, from the most referenced scientific assessments, that have been carried out in educational context, in order to determine their common features and impact on learners, and to identify challenges in terms of design, storyboarding and student monitoring. Thus, we can discuss how far research on MLGs has gone in terms of pedagogical effectiveness and whether there are still challenges that teachers will be facing regarding the design and execution of MLGs. At this level, we try to define the main characteristics of the analysed MLGs, and identify the recurring problems that occur when teachers use them. First, this will allow us to establish several guidelines for designing MLGs. Secondly, in order to diminish the constraints of use, we discuss new ways of implementing MLGs. Furthermore, we propose a global MLGs model, capable of capitalizing the identified main characteristics and overcoming the recurring problems at the same time. Finally, we discuss the possibility of implementing this model through an authoring environment.

Keywords: game-based learning, mobility, location-based learning, teacher, pedagogic objective

1. Introduction

Today, mobile devices such as smartphones and tablets are widespread among teenagers. Indeed, in 2013, 53% of Europeans between 9 and 16 years old possess a smartphone, and 28% of them daily use tablets ((Mascheroni et al., 2013).

This increasing use of mobile devices has recently been followed by the awareness of their potential for learning inside and outside the classroom (Johnson et al., 2013). Hence, many European countries have established digital integration programs in their schools over the last years, such as the *MoLeNET* project in the UK, that can be considered as the world's largest implementation of mobile learning, involving 20,000 learners in 115 colleges and 29 schools (Attewell, 2009). In France, national directives are also encouraging educational institutions to experiment tablets in classrooms. The *"Académie de Nantes" project* for example integrates tablets into schools and reports their affordances for learning and provides detailed findings on their use by pupils[1]. Furthermore, in the USA, 43% of teachers and/or their students use e-readers and tablets in classrooms (Purcell et al., 2013).

However, among all these ongoing programs, the *New Media Consortium (NMC) Horizon Report* (Johnson et al., 2014) shows that there are needs to expand the resources and activities available on these mobile devices in order to make them more suited to teachers' pedagogic objectives.

On the other hand, the concept of learning games is gaining support among educators who recognise that games can increase engagement, creativity, and authentic learning (Papastergiou, 2009)(Johnson et al., 2014)(Aceto et al., 2014).

In addition, now that tablets and smartphones are commonplace, game play is becoming a mobile activity. Hence, mobile games new abilities such as location-based activities (Schlieder et al., 2006) and collaboration (Sánchez & Olivares, 2011) motivated recent work on integrating learning games on mobile devices. In fact, we

[1] http://www.pedagogie.ac-nantes.fr/1369731934531/0/fiche___article/&RH=1162654424937

believe that mobile gaming will fit very well with the behaviour of teens, who are already used to playing games on their smartphones and other hand-held devices such as Nintendo DS[2] and PSP[3].

Although mobile game-based learning is still in its nascent stages, we propose in this paper, to look more closely at certain existing examples of Mobile Learning Games (MLGs).

Through a critical lens, we discuss how far research on MLGs has gone in terms of pedagogical effectiveness and whether there are still challenges that teachers will be facing regarding the design and execution of MLGs.

To answer these questions, we propose to identify five MLGs, from the most referenced scientific assessments, that have been carried out in educational context. We analyse these MLGs in order to highlight their common features and identify the recurring problems of use. This will allow us to establish several guidelines for designing MLGs. Then, we discuss the possibility of creating a MLG design model that integrates those common features and overcomes the identified problems.

2. Bibliographic research of mobile learning games

In this section, we first present our method to identify MLGs having notable success in the research field. Then we describe the procedure for selecting the ones we analyse in this paper.

2.1 Identifying successful mobile learning games

In order to outline our screening set, we decided to focus only on MLGs, which have already been assessed in an educational context. We used the following keywords to search for scientific articles: "*evaluation*" + "*mobile*" + "*learning game*". Then, in order to cover all terminologies used in the field, we replaced the term "*mobile*" by the following terms: "*location-based*", "*pervasive*" and "*contextual*".

Our research method consists in selecting the MLGs that appear among the first results obtained with the above keywords, on four major scientific search engines: *IEEEXplore*, *ACM Digital Library*, *Science Direct* and *Springer*. In addition, to reach a wider scope, we decided to expand our literature search on the meta-search engine *Google Scholar*.

At this point, we chose to retain only the articles evaluating MLGs with executable prototype and described according to the evaluation heuristics defined by Zaibon and Shiratuddin (2010) in terms of game usability, mobility, gameplay and educational content.

Due to the large number of results, we retained only the first ten MLGs appearing on each engine, in accordance with our search criteria and sorted by relevance. Although the algorithm that determines the degree of relevance varies from a search engine to another, it always takes into account the presence of keywords in the full text of the article, the name of the author and the publication in which the article appeared.

Table 1 contains the 50 MLGs obtained with this research method (5 engines x 10 results). There are actually 39 distinct MLGs because some of them figured on several engines (in bold in Table 2). Note that we only mentioned each MLG once per engine, even if it was cited by several articles.

Table 1: The first 10 MLGs found for each search engine

IEEExplore	ACM DL	Science Direct	Springer	Google Scholar
Skillville	On the Edge	Bauboss	**HeartRun**	**The MobileGame**
Lecture Quiz	Chinese-PP game	**HeartRun**	ToneWars	**Explore!**
Skattjakt	**Parrot Game**	QuesTInSitu	**Power Agent**	**Frequency1550**
Bagamoyo Caravan	**Frogger&Floored**	**Frequentie1550**	MobileMath	**Skattjakt**

[2] https://en.wikipedia.org/wiki/Nintendo_DS

[3] https://en.wikipedia.org/wiki/List_of_PlayStation_Portable_games

FreshUp	**Power Agent**	EarlyBird	**Explore!**	**Parrot Game**
Cardinal direction	Kurio	Furio's	Detective Alavi	**Frogger&Floored**
Tower of London	Power Explorer	MSGs	Preserving Famosa fortress	**Power agent**
The Amazing City	iFitQuest	Reenactment	Mindergie	**Lecture Quiz**
CatchBob!	**Explore!**	BoomRoom	Language Learning Game	MuseumScrabble
The MobileGame	TimeWarp	EasyLexia	Nat. Palace Museum Adventure	Mentira

2.2 Selection method

In order to identify the MLGs to be analyzed, we decided to sort them by total number of citations (sum of citations of all articles evaluating the same MLG). Table 2 lists the MLGs shortlisted in Section 2.1, sorted by total citations on *Google Scholar*.[4]

Table 2: Order by total number of citations of preselected MLGs.

MLG	Reference / publishing year	Citations	Total Citations
Frequency1550	(Huizenga et al., 2009)	146	**313**
	(Akkerman et al., 2009)	75	
	(Admiraal et al., 2011)	69	
	(Admiraal et al., 2007)	12	
	(Huizenga et al., 2007)	11	
The MobileGame	(Schwabe & Göth, 2005)	212	**240**
	(Schwabe & Göth, 2005)	28	
Explore!	(Costabile et al., 2008)	104	**179**
	(Ardito et al., 2008)	35	
	(Ardito et al., 2009)	18	
	(Ardito & Lanzilotti, 2008)	11	
	(Ardito et al., 2012)	10	
Power Agent	(Gustafsson et al., 2010)	49	**88**
	(Bang et al., 2007)	39	
Skattjakt	(D. Spikol & Milrad, 2008)	39	**79**
	(Daniel Spikol & Milrad, 2008)	34	
	(Spikol, 2007)	3	
	(Spikol, 2009)	3	

3. Description and analysis of MLGs

Now that we have identified the five most referenced MLGs, we will describe their educational purpose and scenario. We also provide the context and the results of their latest and most complete assessment.

3.1 Frequency1550

3.1.1 Educational purpose

Frequency1550 is a MLG about medieval Amsterdam to be played during a single school day.

3.1.2 Scenario description

In this game, pupils are assigned the identities of foreign workers in medieval Amsterdam who would like to obtain citizenship.

[4] The complete list of MLGs sorted by total citation is available on: http://perso.univ-lemans.fr/~akaroui/table_mlgs.html

Each group of 4 to 5 pupils is divided into a City Team (CT), who will walk through the city, and a Head Quarter Team (HQT), operating from behind a computer in the *Waag* building[5]. After the lunch break, the teams switch places so that every pupil tries the role of both teams. The CT can only view a map of medieval Amsterdam on their smartphones, while the HQT can use two maps, one with medieval Amsterdam and another one with present Amsterdam, and can digitally follow the route of the CT by means of GPS, so they can guide them towards the required learning tasks using internet resources and media information received from the CT. At the end of the day, pupils gather at the *Waag* building for a debriefing session where each group presents their collected media to the other groups and to the teaching staff.

3.1.3 Assessment context

The game was tested on 458 pupils aged form 12 to 16: 232 played the *Frequency1550* game and 226 followed formal lessons on the same learning content (Admiraal et al., 2011).

3.1.4 Assessment results

Frequency1550 players scored higher at knowledge test than those who received formal lessons. According to the authors, the players were able to gain more knowledge through their direct presence on historical sites. It even seems that when students failed at parts of the game, location-based experience enabled them to learn anyway.

In addition, the fact that the scenario was designed in such a way that teams needed to communicate in order to accomplish game tasks (CT sent historical information and pictures found on sites to HQT so that they could find out more about them on the internet), led to a successful collaboration between the teams.

The HQT members were more motivated than the CT members because they felt a sense of control when guiding the CT and because of the diversity of their tasks (internet research, orientation and giving orders).

On the other hand, the authors noticed that some players were distracted by external events such as accidents in the street, and sometimes lost sight of the overall structure of the game. The CT members generally experienced a lack of control and vision of the game. According to some players' interviews, it is also possible that playing the game for a single day is not enough to reach the maximum level of immersion.

3.2 The MobilGame

3.2.1 Educational purpose

The MobileGame is a MLG designed to help new students get familiar with the building and the services on their university campus

3.2.2 Scenario description

The game consist in guiding participants along a map and through several missions to discover places in the university such as the library, the cafeteria or laboratories. Contextual tasks are included in the assignments such as finding a book in the library or a person in a department. Players can play individually or in groups of two, three or four people. Tasks are accomplished through mobile devices and are divided into cooperative and competitive missions. The competitive mission are based on hunting rules: each group tries to catch another group and, is itself hunted by a third group. The handheld device shows the location of the hunter and the prey. The cooperative missions force groups to meet with each other and with teachers in order to exchange information. Again, they are supported with location-based information on their mobile screens.

3.2.3 Assessment context

The evaluation was conducted with 22 students from 19 to 25 years at the University of Koblenz in Germany (Schwabe & Göth, 2005).

[5] http://en.wikipedia.org/wiki/Waag,_Amsterdam

3.2.4 Assessment results

The majority of players (17 of 22), said they would like to play the game again, and 21 thought the electronic support increased the excitement of the game.

Regarding the gameplay, half the participants saw a considerable added value in comparison with a traditional guided tour. Moreover, 8 participants selected “the opportunity to individually explore the university” as one of the three most important positive aspects of the game.

According to the survey, map-navigation activities (moving through the digital map) and ‘*Hiding and hunting’* activities (chasing prey groups and avoiding hunters) obtained the highest score in terms of immersion and distraction.

3.3 Gaius’ Day in Egnathia

3.3.1 Educational purpose

Gaius’ Day in Egnathia is a MLG designed to learn about the archaeological park of *Egnathia* in southern Italy.

3.3.2 Scenario description

Players are divided into groups of 3 or 5. Each group impersonates a Roman citizen (Gaius), who settle down in Egnathia with his family. Group members play different roles: the *reader*; who reads the challenge, *the petitioner*; who consults the glossary, *the navigator;* who carries the map and marks the identified places, the *scouts* who go on ahead to find the places that are the targets of the mission.

The game exists in two versions. The first one is a paper-based version. Therewith, players are equipped with booklets containing the map and the challenges. The second version is implemented by the *Explore!* the mobile learning system. This time, the game information and assignments are displayed on cellphones. Sound effects indicating the beginning and the end of assignments and 3D representations of what places looked like at the time are included in the *Explore! v*ersion.

In both versions, the game is supervised by a game master, whose main tasks are to check that the rules are observed correctly, encourage the players if they run into difficulties, and push them in the right direction by giving them suitable hints. Finally, a debriefing session take place in order to discuss the acquired information. The whole game lasts about three hours.

3.3.3 Assessment context

The article we report describes two studies of playing *Gaius’Day in Egnathia* on mobile phones (*Explore!* version), aiming to compare behavior, engagement and learning with the original paper-based version.

The first study involved a class of 24 students, from 11 to 13 years old, playing the paper-based game. The second study involved a total of 42 twelve years old students; 19 of them played the paper-based version and 23 played the *Explore!* version.

3.3.4 Assessment results

The results indicated a positive reaction to *Explore!* version. 74% of the students explicitly reported having preferred *Explore!*, only 13% preferred the original game and 13% did not express any preference. The 3D reconstructions on mobile screens during the gameplay and the debriefing, were the primary reason for preferring *Explore!*

However, results showed more right answers in the game assignments for the paper version. The authors explain this difference by the fact that the *Explore!* version showed only relevant information corresponding to the exact GPS position of students while in the paper version, students always had access to all the data. Additionally, the *Explore!* version required students to respond to the questions in a certain order while in the paper version, they could choose the order of their answers and even return to some of them later in the game.

Motivation was very high in both versions of the game but even more so for the *Explore!* version. The motivation factors were related to the used artifacts (such as the sound and augmented reality effects) for the *Explore!* version, while for the paper version, they were related to the archaeological park.

3.4 Power Agent

3.4.1 Educational purpose

Power Agent is a MLG designed to educate players about energies and teach them good consumption habits.

3.4.2 Scenario description.

Players take the role of a special agent whose mission is to save energy at home. To achieve this goal, the agents act under the supervision of their director "*Mr. Q*". Each agent is equipped with a mobile phone connected directly to the electric power meter in their home and must cooperate with the members of his family to reduce consumption between 5PM and 10PM. Then, his efforts are combined with other agents in the same city. The team of special agents is in competition with another team in another city. The winning team is the one that decreases its energy consumption the most over a defined time period.

3.4.3 Assessment context

Two teams of three agents, along with their family members, participated in the game for 10 days in two different cities in Sweden during the spring of 2008. Coincidentally, the first team consisted of three boys and the second team consisted of three girls.

3.4.4 Assessment results

Players were highly motivated and committed to the game and accepted a lower daily comfort level than the standard. According to the authors, the configuration of the two teams (girls' team and boys' team) improved the competitive aspect of the game. Thus, they recorded several outstanding initiatives among agents such as replacing light bulbs with energy saving ones or using candles.

Collaboration aspect within families was considerable and an important immersive factor. Indeed, parents were quite involved in the game and even communicated with *"Mr.Q"* through their children. The educational objective was also achieved in most cases: players learned new methods to reduce consumption through the strategies exchanged on the game's web platform, by applying these strategies and discussing with their family and team members.

The MLG led to considerable changes in behavior during the 10 days period of the game but the assessment did not allow to measure the long-term effects.

3.5 Skattjakt (treasure hunt)

3.5.1 Educational purpose

Skattjakt is a MLG designed to promote physical activity and collaborative problem-solving while learning about history.

3.5.2 Scenario description

The game takes place in a castle. The main assignment is to help the ghost of *Anna Koskull* (former lady of the manor), to solve the mystery of her missing husband, who actually built the castle. While exploring the map displayed on their smartphones, players receive text and audio based clues to find landmarks. Therewith, they have to solve puzzles, spell out codes and collaboratively unscramble clues directing them to other landmarks. Moreover, they lose time each time they give wrong answers.

3.5.3 Assessment context

The study that we report, was firstly carried out on 12 pupils between 12 and 15 years old during the winter in 2007, and secondly, on 26 girls aged between 13 and 15 years old, during the summer of the same year.

3.5.4 Assessment results

For the first experiment, 58% of players said the game was very entertaining and 73% for the second one. This could be partly related to the weather conditions in which the game took place (Swedish winter vs summer). The gameplay also increased motivation to learn. Indeed, 100% of the players appreciated learning local history through the game in the second experiment and 75% gave the same feedback after the first experiment. Furthermore, even collaboration improved during the second experiment. The results indicate that 92% of the players in the second experiment (who were only girls) were able to collaborate all the time against only 58% in the first experiment.

4. Discussion

All the analyzed MLGs obtained good results in terms of learning effectiveness and high results in terms of gameplay satisfaction. So, we will firstly identify the common features which contributed to these games' success. Secondly, we will discuss the problems faced by players during the games assessments in order to analyze them from a design point of view (teacher's position).

4.1 Common features

4.1.1 Location-based learning

Location-based activity is a common feature to all the analyzed MLGs. It is obviously a pedagogic choice to use location-based activities as a learning mechanism. When games use this feature, they are called Geogames, according to (Schlieder et al., 2006). At this level, we can say that our analysis set consist of five Learning Geogames.

Given some of the assessments results, we conclude that the location-based experience is an effective way for learners to acquire information because of their direct presence on the learning spots, the possibility of observing and therefor better memorizing places, names and functions. Indeed, *Frequency1550* players have scored higher in the knowledge test, than those who had received formal lessons. Furthermore, pedagogical information in this game was sometimes acquired indirectly: players didn't always succeeded the game's assignments but always learned something from the context around.

Location-based learning also helped both teams that played *Power Agent* to learn about the required consumption habits in a practical way. Truly, we believe that it is more efficient to directly practice the learned methods in a realistic situation rather than just receive them in a theoretical form.

4.1.2 Learning autonomy

One of the most important elements characterizing Geogames is the moving ability. This feature fits ideally with the autonomous learning method. Actually, many studies recommend autonomy in learning because it is closely linked to motivation. Indeed, personal involvement in decision making leads to more effective learning (Dickinson, 1995)(Knowles, 1975). Autonomy is also valued by the players. Indeed, the majority of *The MobileGame* participants selected the possibility to individually explore the university as one of the most positive points of the game. In addition, the players of *Gaius'Day* who could freely answer the questions, scored higher than those who were constrained to answer in the implied order. Moreover, CT members in *Frequency1550,* who had less autonomy than the HQT, expressed less satisfaction for the gameplay.

Hence, we recommend more autonomy of movement and decision when designing MLGs scenarios. Indeed, we believe that enabling students to find items, explore sites, and choose strategies increases personal involvement and hence, leads to more effective learning.

4.1.3 Role-playing pedagogy

Role-playing was common to four of the five analyzed games. Indeed, in *Frequency1550*, players had to play the role of foreign workers in medieval Amsterdam, roman citizen in *Gaius' Day*, special agents in *Power Agent* and investigators of a fictional research group at the university in *Skattjakt*.

Role-play has been often used in education as a learning mechanism. (Heuser, 1999) for example used role-play to cultivate college students' understanding of poverty and homelessness in the United States. It has also been used with high school students in South Africa as part of a repertoire of activities for "multimodal exploration of texts" (Stein, 1998). In addition, since it requires students to embody characters and perspectives that may be quite different from their own, role-playing activities can be cognitively challenging (Shapiro & Leopold, 2012). Thus, we believe it can be a valuable addition to the gameplay experience and we recommend to integrate it in MLGs scenarios if there are suitable conditions.

4.1.4 Collaborative learning

Setting up collaborative activities between players is recognized as one of the mechanisms that enhances games. This is due to the social interactions and the extra challenge of team decision making (Marfisi-Schottman et al., 2014). Indeed, cognition is better when it becomes a result of a distributed process across members of a group (Hollan et al., 2000). All the analyzed MLGs in this paper include collaborative learning methods since all the studied scenarios were based on group problem-solving. Hence, social interactions were promoted. For example, the involvement of the whole family in *Power Agent* improved the immersion of agents and made the game more challenging for them. Moreover, the authors reported that the randomly composition of teams by a girls' and a boys' team improved competitiveness. In addition, collaboration has been more successful among the girls teams compared to the mixed team in Skattjakt. This leaves us to say that, in some cases, it is possible to draw profit of the competitiveness aspects between the sexes to promote engagement. Social and epistemic factors, such as age and relationship between players, can advantageously be taken into account to facilitate the design of such competitive activities (Hamalainen, 2008).

4.1.5 Innovative digital tools

Innovative digital tools makes the learning process more attractive. Indeed, according to the games observations, motivation was always higher when it integrated new digital tools. The experimentation of Frequency1550, for example, showed that players were more attentive and reactive when teachers explain how to use the mobile devices than during the explanation of the game's history. The augmented reality (AR) features also seemed to motivate *Gaius' Day* players and the 3D representations provided by *Explore!* allowed richer after-game discussions and a longer debriefing phase than the paper version. We therefore preconize combining AR techniques like QR/Flash codes and sound effects as well as including multimedia content to enhance MLGs attractiveness.

4.2 The problems of use

In this part, we will analyze the problems encountered by players during the gameplay and interpret them through the teacher's lens in order to determine possible solutions.

4.2.1 In terms of gameplay

Some players of *Frequency1550* lose sight during the assignments time and were distracted by external events. To overcome this kind of circumstances and to avoid distractions in general, a game master should always be planned in MLGs scenarios. The teacher can advantageously incarnate this role. Indeed, we believe that the monitoring progress is particularly well suited for the teachers so they can help players in difficulty. Therefore, providing MLGs with tracking tools so that teachers can supervise the players' progress in the game could be very useful. Providing alternative paths in the game scenario and additional activities would also be an efficient solution to manage the different levels of player's.

4.2.2 In terms of design

Skattjakt players regretted that it was impossible to play the same game on other topics than history. Similarly, the authors of *Gaius' Day* (tested on *Explore!*) expressed their needs to make their authoring tool more generic to other topics besides archeological parks. Currently, there are several authoring tools allowing to design and execute Learning Games such as *e-adventure*[6] and *Storytec*[7]. However, these authoring tools do not provide the means to design located-based activities or using innovative digital tools which are essential to MLGs.

[6] http://e-adventure.e-ucm.es/

[7] http://www.storytec.de/index.php?id=2&L=1

Consequently, we believe that a generic model and tool for designing and executing Learning Games on mobile devices would be very advantageous. Therefore, our future work will be focused on establishing such a generic model. We will concentrate on integrating the previously identified MLGs features in our system's database in order to guide designers to create MLGs in the most efficient way. Nevertheless, possibilities of reification of this model are multiple since we can take advantage of the existing authoring tools cited above. Thereafter, (Figure 1) illustrates the process that we will set up for our authoring environment in order to assist the designers to create their custom MLG.

5. Towards an efficient mobile learning games design model

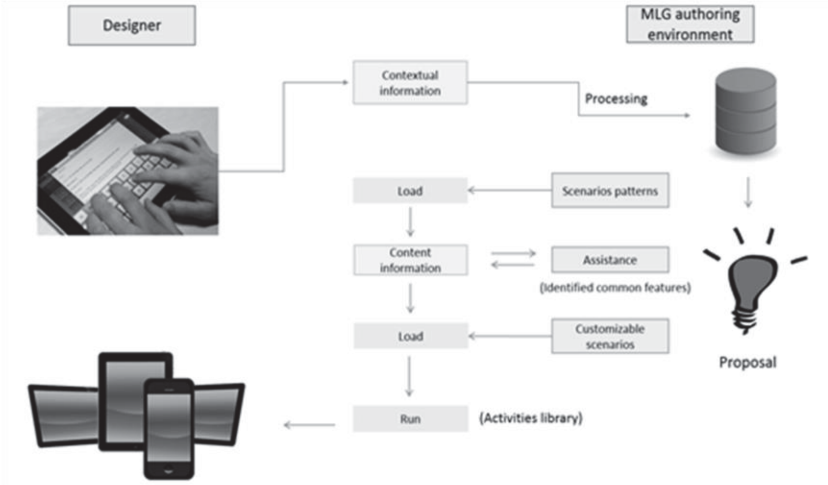

Figure 1: The MLG authoring environment process

The process takes place primarily between the designer and the authoring tool system. The idea of the operating method is that designer inserts information about context and content of his MLG and that the system gradually propose components (e.g. scenario patterns) and support (e.g. findings of this review) based on the provided information.

6. Conclusion

In this paper, we sought to identify the principal common features that contributed to five MLGs success. On the one hand, we found that location-based autonomous learning, role-playing pedagogy and collaborative learning were the main features of the analyzed five MLGs. On the other hand, we exposed particular design and gameplay problems to which we have proposed possible solutions; such as the risk of distraction especially when playing outside and the question of managing different players' progress in the MLG. Although we have identified interesting MLGs, our research method leaves out recent MLGs whose articles have not yet been much cited, but who potentially implement several mechanisms found in the last part of this article. For example, *Power Explorer* is a MLG that enhances the learning process found in *Power Agent* in order to achieve long-term changes in consumer habits. The next step of our work is to define a generic authoring environment for non-computer scientist such as teachers, museum curators and park managers, so that they can design their own games and deploy them on mobile devices.

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Seriously, Electricity is no Game: Play Safe

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Abstract: Over the last two decades we are witnessing an accelerating paradigm shift in electricity grids and markets. The power grid, enabled by technologies such as renewable energy sources (RES), microgeneration, telemetering and telecontrol, is moving towards demand side management, under the pressure for energy saving and low carbon economy on the one hand and electricity market deregulation on the other. Demand side management requires the user to be an active agent interacting in real time with the grid and the markets rather than a passive consumer whose only interaction with the gird is paying the bill and reporting faults. Under this light, the majority of electricity users could be considered as technologically illiterate, lacking fundamental knowledge and skills, which hinders the uptake of technologies and distorts related policies. *Smartege* has been designed and developed as a gamified application to educate electricity users, regardless of their profile, and modify the way they perceive their relationship with the electricity grid. To that end, persuasive modeling, gamification and cognitive learning have been used in a synergistic way. The expected learning outcomes of the user are to know, understand, apply basics of electricity use and generation towards efficient energy management as well as to analyse, evaluate and create energy efficient scenarios. Existing applications, such as Electric Box, Energy Quest, Ollie's World, Electrocity, Power Matrix, Energy Ville, et. al., focus mostly on children's and teenagers' conditioning towards a more overall 'green' attitude; address only one type of user's interaction with the electricity grid; or, are designed to promote commercial products and processes. *Smartege* on the other hand is a game of roles, simulation, strategy, quizzes and learning. The game uses an engaging graphical user interface that emulates the basic daily functions and activities of an electricity user in a house and an office building, in real time. Using gamification mechanics, the user is guided to understand the energy profile of appliances and equipment operating in the virtual buildings with respect to user-defined set points, to evaluate the effect of his/her actions and habits on them, to analyse the costs and benefits associated with energy upgrading or saving tactics. The user is gradually allowed to 'produce' electricity in the quest for net Zero Energy Buildings. The user's knowledge base is improving through various content forms, such as tips, information, reading material, quizzes, exercises. The user is triggered at appropriate times with engaging messages and is motivated by counters, reputation points, leaderboards and badges. Special emphasis is given in the game's social dimension, employing social media, promoting user's interaction and information exchange for gaining points. Finally, at advanced levels, by purchasing appropriate hardware, the user can emulate, monitor and control the electricity use and production of a real installation.

Keywords: Smartege, energy behaviour modification, gamification, education

1. Introduction

Constantly increasing energy needs of our civilization and emerging trends in electricity grids and markets converge in the need for demand side management, in which the end user has a pivotal role. However, the rapid and spectacular advances in technology along with poor design and funding, have left mass educational systems lagging behind and most of technology end users in awe, misinformed, alienated, and easy to manipulate. Over the last decades, the deregulation of electricity markets and the Renewable Energy Sources (RES) technology have accelerated the emergence of distributed generation. This along with advances in ICT technology have led to the smart grid and demand side management technology as opposed to the conventional transmission grid and supply side management. In the new paradigm, the electricity user interacts in real-time with the provider, the grid, the markets (Burgess & Nye, 2008). Electricity user behavior is therefore of fundamental importance in the future grid design and control.

The new paradigm calls for an educated electricity user who will be able to read and understand his/her electricity bill, monitor and control his/her consumption profile, intervene in the electricity market by buying or selling (micro-generated) electricity at competitive prices, understand the idea and contribute in realizing net zero energy buildings (nZEB). Dealing with these contemporary problems, the behavior modification approach is a powerful tool towards shaping savvy electricity end users.

Gamification, loosely defined as a practice of using gaming technology and mechanics in non-gaming contexts, first appeared in the fields of digital media and marketing in 2008 (Deterding et al., 2011), became widely known two years later and, according to the Gartner Hype cycle, it approaches the 'plateau productivity' region faster than most emerging technologies. Gamification has already been applied in a) formal education in the traditional classroom environments as a complementary learning tool or in e-learning and distance learning platforms (Dominguez, et al, 2013; McCombs and Vakili, 2005; Lee and Hammer, 2011) and b) in informal education and behavior intervention or modification (Carr, Taylor, Hunt and Mejia, 2014; Mohr, Schueller, Montague, Burns and Rashidi, 2014).

Smartege, the gamified application presented in this work, does not intend to replace conventional teaching methods, nor be a commercial application for attracting users - clients. *Smartege* aims at combining the educational and commercial potential of gamification, in a new methodology for application development and use it to lead users, through education and increased involvement, to engage in good practices, activities and actions associated with electricity consumption, production and energy saving.

Our approach is based on Fogg's Behavioral Model - FBM (Fogg, 2009), a model developed for persuasive design targeting behavioral modification. The proposed methodology uses the cognitive approach (Bloom & Krathwohl, 1956) for capacity building and gamification mechanics alongside the lines of the flow model (Csikszentmihalyi, 2000) for user engagement. We have applied this method to design an online application for smart phones and tablets targeting the technological literacy and behavioral modification of electricity users.

FBM postulates that individuals are convinced to change their behavior on an issue, when three conditions are satisfied: sufficient motivation, adequate capacity and efficient activation (Figure 1). The right time for intervention (activation) is when the point determined by the capacity (horizontal axis) and the motivation (vertical axis) of the individual has a value greater than the value of the threshold needed for achieving behavior modification. In other words, the right timing is when a person is able and motivated enough to implement change and the only thing missing is the trigger that will activate it.

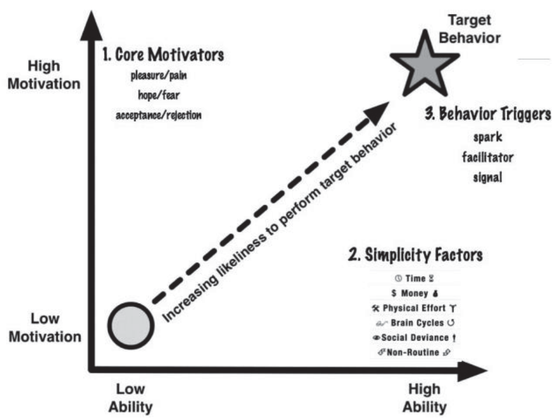

Figure 1: FBM is determined by three parameters: ability, motivation and activation (trigger) (Fogg, B.J. 2009)

Smartege aims at the behavior modification of the electricity user from one who is a passive electricity consumer to one who interacts with the demand side managed grids and deregulated electricity markets. To accomplish this, the users must 1) increase their ability to do so through education in the basic elements of electricity generation, distribution, consumption and saving 2) be motivated 3) triggered to do so at the right moment.

The educational content, designed to increase the ability of users (FBM horizontal axis), is based on the cognitive learning model where the student from passive knowledge receiver becomes an active partner in the process, employing actions, rational thinking, and interaction with others and the environment, in an effort to give meaning to the subject matter that he/she attempts to understand or conquer. In this content, knowledge acquisition becomes a personalized affair of the subject, defined and guided by it.

To increase motivation (FBM vertical axis) and trigger behavioral change, towards the defined objectives, gamification mechanics are employed according to the flow model (Csikszentmihalyi, 2000) which postulates that if the task of the person is too easy, the user's status is converted to laziness while if the task is very demanding, the user becomes frustrated, anxious and usually abandons the effort. First, the motivation matrix is developed (Fig.2) and next, content is adjusted according to this matrix. All three FBM motivator dipoles, namely, pleasure/pain, hope/fear, social acceptance/rejection (Fogg, 2009) are used for motivation and triggering.

2. Ability, motivation and triggering

The educational content used to increase the user's ability to implement change and shift towards the right of the horizontal axis of Figure is developed following the student-centered approach. First, learning outcomes are defined following the learning pyramid of Bloom's taxonomy (Bloom et al, 1956): *know, understand, apply, analyze, evaluate, create*. In a gamified application, to achieve maximum motivation and high educational impact, the learning outcomes must a) be precise, clear, and in line with the game's objectives and environment b) refer to incremental goals of increasing difficulty and complexity in line with the game's levels c) produce the feeling of challenge to the user (Ling, K., Beenen, G., Ludford, P., Wang, X., Chang, K., Li, X., et al. 2005).

The *Smartege* user, as a consumer, is expected to: know the basic notions and definitions of electrical energy; understand the relationships between the electrical energy quantities; apply this knowledge to a building's energy management; analyse the energy profile of a building; evaluate the energy performance of a building; create energy efficient scenarios for energy management.

The *Smartege* user, as an electricity producer and agent, is expected to: know the basic notions and definitions of electricity production and market; understand the relationships between the electrical energy production and consumption; apply this knowledge to the management of small RES installations and electricity trading; analyse the techno-economical profile of a RES installation; evaluate the performance of a RES installation; create energy efficient scenarios for RES management.

These learning outcomes are directly linked to the levels of the game described in the following section as well as the tasks and missions.

Next, the educational content, consisting of definitions, explanations, advice, reading material, libraries, quizzes and problems, is developed also based on Bloom's taxonomy.

After the learning outcomes have been defined, the Motivation Matrix (Fig. 2), one of the major instruments used in gamification, must be designed.

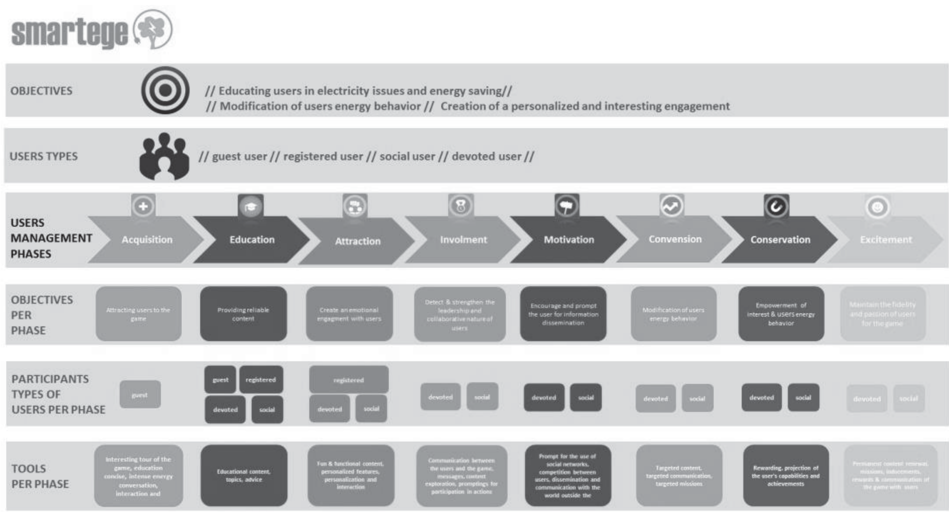

Figure 2: Smartege motivation matrix

Depending on the phase of the motivation matrix, the users are divided into the 4 main categories, namely guest, registered, social and devoted. The application approaches each user category in a different way (Constantos et al, 2015): The guest users category involves the players that first enter the game either because they want to explore it or because they want to play. After they complete the tutorial, they are redirected to the registration page to continue the game. The users that will complete the registration step are automatically assigned the registered status and, depending on the moves they most frequently perfrom, are categorized as social or devoted. Social are the users who are mostly keen on actions such as share, like, comment. The most important user is the devoted one because he/she is the user that is most likely to take the game to its end and gain the most out of it. The devoted user is likely to be the first user type to implement behavioral change.

The phases of the motivation matrix are presented:

- Acquisition: One of the most important phases aiming to attract users to the game environment, through an engaging browsing process during the tutorial level.
- Education: This phase of training users in energy matters spans the game from the tutorial to the end, providing trusted content sources and information to users. Educational material includes reading materials, useful links, tips, definitions, explanations, advice, problems and quizzes.
- Attraction: In this phase an emotional connection between users and the game is created after having spent time with it. Actions and tools serving this phase are entertaining and functional content and the personalized features of the game. As the user spends more time into the game he/she is recognized by the system and receives personalized and more engaging messages. Moreover, the system recognizes user's level of education and guides him/her to higher levels of education and knowledge.
- Involvement: This phase focuses on identifying and strengthening the leadership and collaborative nature of users. This means that, through the game, users trust their decisions more over time, they get more involved with their building installations, develop their leadership skills and are more likely to assume responsible roles in the game as well as in the real world as the time goes by.
- Motivation: This phase is very important because through encouragement and inducement each user is able of forming a network around him, where the dissemination of information and awareness brings other users within the game, who previously were not aware of, leading to a social viral activity. The tool to achieve this is to prompt the use of social networks, the competitions between users and the diffusion and communication with people outside the world of the game. This raises the user's awareness to energy matters and makes them compete for full knowledge acquisition.
- Conversion: This phase refers to the top objective of the game, which is the modification of the user's energy profile and attitude in related issues. This is achieved with more specialized tools such as targeted content, targeted communication and targeted missions. This phase is activated as the user spends more time in the game and is getting accustomed to it as well as *Smartege* knows more about the user via the user's profile updating and sends him/her more material which is closer to his/her energy profile and other preferences.
- Conservation: This phase aims in maintaining and strengthening energy behaviors that have shifted in the right direction. Users are encouraged to "carry" the actions they performed in the game in real world settings and conditions. This functionality is supported mainly by the final level of the game.
- Excitement: The last phase of the motivation matrix is based on the interest and passion of users for the environment and in the fact that at this stage, is possible to create emotional commitment that will make users return in the game. The tools to achieve this are the constant renewal of the content, quizzes, prompts and communication with the user to keep him/her in the game and attract other users to it.

To guide the *Smartege* user through the stages of the motivation matrix all three FBM motivators:

- pleasure / pain is employed in such way that the balance between the user skills and the difficulty of operations the user is required to perform keeps the user in the flow region; this dipole is served by 1) the ranking of the user in the leaderboard 2) improvement or not of his classification 3) prizes 4) the amount of accumulated points. The increase or decrease of "wallet" points is directly linked to the economy of the game. Users' in-game actions, such as the optimal use of electrical devices or the energy upgrade with new ones, define whether their wallets points raise or decrease. The user is pleased when he/she sees his/her wallet points grow through successful missions or correct and timely moves and experiences pain and frustration when he/she loses points or sacrifices a certain amount to improve his/her position in the game in the long-run. Then, the user is triggered to gather more wallet points by participating in new demanding missions.

- hope / fear is activated by the opportunity to exploit the benefits of the application, to unlock a level or be locked out of a level. The "fear" of stagnation and exclusion of the user from new content or from the application itself, is related to the real world potential exclusion from new technological developments. Unlike the conquest of the application's levels, this mechanism is related to the conquest of knowledge and expertise that can be related to the real world. The inability to exploit in full the potential of the application acts as a reminder that his/her training is not yet sufficient.
- social acceptance / rejection is a powerful dipole in gamified applications which can be linked to the use of social media. The user is given the opportunity to 'see / observe' the movements of others, to shape his/her profile / position in the 'market', to compare positions and actions with others, to view other user profiles, their rankings in the leaderboards and generally to compare his/her own achievements relative to other users. Users are encouraged to take action and match or outperform other players who have better statistics, consequently feeling greater social acceptance. Furthermore, the user can invite friends and eventually form in this way an identity and achieve a certain status in the *Smartege* world.

To achieve the above, *Smartege* uses all three FBM stimuli (Figure 1), namely: a) Sparks which are messages for unmotivated users and are related to the three motivational dipoles above, such as risk messages, warnings, award announcement, exhortations; for example, a warning message when the facility operated by the user has very high consumption b) Facilitators are designed for users with low ability and are usually in the form of advice; for example, a message prompting the user to answer a quiz for point collection to be redeemed in appliance upgrading improving his/her consumption profile c) Signals that act as reminders to sufficiently motivated and educated users; for example, a message that the heater is still on is issued.

3. The game mechanics, design and elements

The game has four counters: a) 'Wallet points' which accumulate when tasks and missions are accomplished, are spent when higher energy class devices are acquired and installed, and are lost when resources are managed poorly b) the 'Electrical Energy counter' which emulates the energy meter recording energy consumption and production in kWh c) the 'Green bar' which monitors the virtual buildings' energy class d) the 'Comfort bar' which monitors the comfort level in the building, according to existing standards and design specifications (Constantos et al, 2014). All four counters must be within acceptable ranges in order for the user to advance in the game.

There are four levels in the pilot *Smartege* version:

- The first level is a *Tutorial* intended to attract and engage the user; it offers a virtual 'tour' of the application and introduces most of the game elements that will be encountered in the game. In this, the user is also asked to answer a set of quizzes to accumulate points. If users fail, they are prompted to read appropriate educational material available in the 'library' and take the test again. This level is of high educational value and therefore mandatory.
- When the second level, *Flat* (or Residential) level (Figure 3) unlocks, the user is invited to select from the application's "inventory" typical home electrical and electronic appliances such as refrigerators, stoves, washing machines, dishwashers, TVs and computers, and position them in the virtual flat he/she is going to manage. When the user touches the appliances and devices placed in the Flat, tips and information about their electrical energy specifications appear. With the help of appropriate triggering and educational material, such as recommendations, explanations and definitions, the user is led to schedule the operation of the selected appliances to optimize the electricity consumption as well as the comfort level in the Flat. The user may increase the energy class of all buildings under his/her control by replacing existing appliances and devices with others of higher energy class, by spending 'Wallet points' accumulated through the successful completion of tasks and missions.

Figure 3: The 3D graphic user interface of the flat level

- The next level is the *Office* (or Professional) level (Figure 4) and unlocks after the user has managed to reach A-class efficiency in Residence level, utilizing the experience and knowledge gained so far. To allow for the attainment of the ultimate goal of net zero energy consumption buildings (nZEB), electricity microgeneration is enabled from this level on. The user first learns to optimize the electricity use and consumption of all his/her buildings, residential or professional, and then is allowed to use 'Wallet points' for the installation of electricity generation components. The concept of electricity production is a very important one in the game, since it allows the user to think of electricity as a resource and not simply as a costly comfort enabler. The user is also granted access to educational material concerning electricity generation and storage devices, such as photovoltaics, wind turbines and batteries, as well as the relevant legal framework.

Figure 4: The 3D graphic user interface of the office level

- 'My Home' is the last level where the user can a) simulate the electricity use of an actual installation, e.g. his/her house b) with the acquisition of appropriate hardware, monitor the electricity use of the actual installation per appliance or electricity line, and have full control of it, setting operating points and allowing remote on/off. At this last level, the user is given the opportunity to relate what he/she has learned to the real world.

The mechanics described above are combined with progression metrics that calculate the user's progress in the game depending on the motivation of the phase in which he/she is. These include levels, rewards, leaderboards and missions seeking to transform the negative emotions to positive ones and keep the user in the 'flow' zone of the game. The *Smartege* leaderboard is called 'Tesla's Followers' (Figure 5) and the user's ranking in it depends on the points earned though the progress of the game.

Figure 5: TESLA's Followers: The Smartege leaderboard

4. Diversification of SMARTEGE compared to existing applications

Most existing energy related games or gamified applications aim at raising ecological awareness at relatively young ages or allow the calculation of the energy consumption and CO2 emissions of appliances or devices. Certain applications, such as Electrocity, Power Matrix, Energy Ville, are adult strategy games employing energy related narratives. *Smartege*, on the other hand, aims not only at educating or entertaining but also modifying the behavior of adult electrical energy users. In this sense, potential *Smartege* users are all electricity users, regardless of age, race, sex, or economic background. Electricity users can be divided into the following broad categories with respect to their use of electrical energy: 1) domestic users who are responsible for paying the electricity bill of their residence 2) domestic users who are not responsible for paying the electricity bill of their residence, *e.g.* children financially dependent on their parents 3) users at the workplace or school who are not responsible for paying the electricity bill of the facility, *e.g.* employees in an office or students in a classroom 4) users at the workplace who are responsible for paying the electricity bill of the facility, *e.g.* building managers.

Smartege is at the same time a game of a) simulation, because it simulates the consumption and production of electricity based on actual building requirements (residential and professional) b) strategy, because it requires the users to set objectives and use optimally the tools and resources provided to them c) learning & training, because the application provides the user with learning material d) quizzes, since many of the 'tasks' of the application are multiple choice questions based on the learning.

In conventional games, the user's engagement with the game decreases as it approaches its end. In gamified applications, like *Smartege*, the mechanisms that make the game interesting for people and keep them engaged are the same mechanics that increase user involvement in the course of time.

5. Conclusion

A new methodology for developing educational gamified applications is presented which is based on persuasive technology, cognitive learning and gamification. This methodology has been applied to develop *Smartege*, an application for mobiles, tablets and PCs targeting the modification of users' behavior, in view of the changing role of the electricity user in smart grids and electricity markets. *Smartege* addresses all electricity users independent of age (maybe excluding young children), gender, race, education and financial, social or professional situation, as we all use electrical energy. The user's ability is increased through educational content which has been developed following the student centered learning approach. Game mechanics are employed to motivate and trigger the user towards the desired behavior. *Smartege* aspires to enable users to tranfer knowledge and good practices acquired through the game to real world cases. To this end, the application supports the option to manage an actual installation, such as the user's house or office, using the game's familiar to the users environment, via appropriate monitoring and control hardware. The pilot application is currently under test and results will be reported in a future article. Future versions of the application are expected to support more types of virtual buildings with distinct energy profiles, such as hotels or schools, and allow for actual competition between users emulating an energy market environment with the game administrator in the role of the market regulator.

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April 9th 1940, the Nazis are Coming: A Correlational Study of History Game's Mixed Effects on Knowledge, Attitudes and Thinking Skills

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Abstract: Thinking historically requires more than knowing what happened in the past. Building historical competences is a transformative process which trains a suite of cognitive and psychological skills including historical empathy, imagining counterfactual scenarios, and reflecting on the uses of history. This set of "second-order" competences is in essence what allows us to infer potential routes for the future by comprehending the past. Based cross-disciplinary empirical collaboration between history, didactics, game design and psychology, this paper explores data from "The Dilemma Game 9. April 1940": A design that illustrates the potential for bringing counterfactual historical scenarios to life though scaffolding at both the substantive first-order level and the more procedural cognitive/abstract second-order level. The challenge for researchers interested in the psychological processes that underlie 21st century historical thinking skills, then, is how to assess the transformative powers of games and other pedagogies in terms of domain-invigorated, but not content-bound, cognitive skills and attitudes, rather than regurgitation of facts that any child can Google in a heartbeat. Per usual, significant learning gains were observed at the level of substantial, or "first-order", knowledge and related increases in confidence, but a shift was also observed in the second-order concept of historical empathy. Sadly but perhaps predictably, the largest gains in substantial knowledge were associated with text-reading rather than enjoyment, counterfactual exploration, or perceived usefulness. Different play styles, from reading text to looking for maximal carnage was, however, related to a wide spread of attitudes and self-reported thinking habits, including historical empathy, using historical knowledge to form opinions and the understanding that history is sometimes about imagining what could realistically have happened instead of the few things that did turn out to shape our histories.

Keywords: history, systems thinking, counterfactual thinking, 21st century skills, play styles, game effects, correlation

1. Introduction

In this paper we discuss two sides of history learning, scaffolded through an online dilemma game. Denmark was invaded by Nazi forces on April 9th 1940. By all accounts the occupation was a largely peaceful affair, and historians have argued that Denmark *might very well* have been counted with the axis coalition in the war-aftermath, had a few groups of freedom fighters not fought the Wehrmacht, especially in the latter part of the occupation.

Such "if only" reasoning is a central part *counterfactual history thinking* – the merger of cognitive skill and background knowledge that allows us to construct alternative scenarios for what *might* have happened at different historical junctions.

In *the dilemma game April 9th 1940*, students get to walk a mile in Danish Prime Minister Thorvald Stauning's shoes when the Nazi war machine was approaching and as the occupation became a political reality.

This is an explorative investigation of the immediate effects this game had on players, and predictors of such shifts in knowledge, attitude and historical thinking skills: Beside the more traditional "substantive knowledge" concerned with information about "when", "who" and "what really happened", we explored different self-reported indices of historical thinking, combined with intrinsic motivation, (Intrinsic Motivation Inventory 1994; Ryan & Deci 2000; Deci et al. 1999),transportation into fiction (Green & Brock 2000) and play styles afforded by the game design.

In order to measure effects of games we need a high degree of methodological stringency including clear hypotheses with appropriate instruments and comparison parameters (Lieberoth et al. 2015). Formulating those takes a lot of exploratory work through multiple lenses, which is left out of many research publications (Lieberoth & Roepstorff 2015). As such, most of the present analysis is an exploratory mapping. The aim was to identify theoretically and mathematically meaningful correlates as mediators (control variables) for further research.

Instead of going straight for hard hypothesis testing, we present this at a midwaypoint in our research, while it is still OK to be curious – to ask open questions, explore different ideas in parallel, and shoot a buckshot-like cloud of variables in the general direction of our game, in the hope that one or two of them will hit home, and enable us to ask even more interesting and well informed questions in the next stages of our research.

2. Teaching history in a new millennium

The educational landscape has seen major shifts in the new millennium. Some ideological, some scientific and some institutional. At the core of reforms and budding paradigm shifts lies the question: What are the competences that children will need to succeed in the 21st century? For instance, science writer Paul Tough (2013) popularized the notion that while IQ and similar standardized tests are somewhat useful predictors of school performance, attributes beyond the purely cognitive seem to be much more indicative of how well a young person will do in life. These attributes include non-cognitive factors (Anger 2012; Lleras 2008; Leininger & Kalil 2008) like self-regulation, curiosity and trust. Importantly, they can be built or decimated by life-circumstances including schools and caregivers, and have been recognized as a potentially important economic development factor (Cunha & Heckman 2008). The history subject must be considered as part of this educational climate.

2.1 21st century skills in history education

The success of Tough's storytelling about non-cognitive skills illustrates a new discourse where schools need to focus on inclusion and life skills in addition to core curricula.

If we look past the fundamental dilemma that, in lieu of actual working crystal balls, schools will never be able to truly prepare students for the vagaries of an unknown future society (Dewey 1900), the idea of 21st century skills represents a push to look beyond curricular separations and purely cognitive skills, in order to focus on capabilities that transcend content and context.

Although there is no canonical list, according to The National Science Teachers Association 21st century skills can be roughly sorted into into "core subject knowledge; learning and innovation skills; information, media, and technology skills; life and career skills; adaptability; complex communication and social skills; non-routine problem solving; self- management/self-development; and systems thinking" (2011 p. 1 - for other categorizations, see McComas 2014; Saavedra and Opfer 2014).

While the "new" idea of 21st century skills can be seen as fundamentally boundary spanning, similar notions have appeared from within established school domains.

In history, for instance, the cognitive and practical skills needed to "think and do" history rather than "just knowing about it" has become acknowledged as *second-order* concepts, which have been framed as both active/procedural/cognitive abilities and higher-order understandings. In this framework, concepts like *evidence, cause, change, development, significance* and *empathy* were introduced as central to thinking-skill oriented curricula in addition to "substantial" first-order content like *nation, war, World War 2, Nazism* and *representative democracy* which are tied to time and place, and therefore not constant and generally applicable like the second-order key concepts (Lund 2012; Lévesque 2005). In order to make sense and create a higher level of historical awareness, however, first- and second-order concepts need to interact. This can happen in teaching, play, problem-solving, reasoning, conversation and a lot of other practices well known to 21st century education. *The key concepts are only given meaning in symbiosis with the substance, the subject matter* (Lund 2012, 99, my translation).

Some of the "second-order concepts" are thus fairly specific to historical reasoning, while others mirror more domain-general abilities. Out of the net lists of 21st century skills, for instance, information seeking and systems thinking are at the core of the ability to appropriate and analyze source information, and placing that in the context of the more complex procedural whole. Historical views of evidence, on the other, hand is a cognitive parameter more narrowly applicable as part of the history subject domain.

With this point of departure we feel confident in asserting that there also exists a distinctive brand of 21st century historical thinking, out of which media literacy, systems thinking including counterfactual reasoning are central components, along with the list of second-order or procedural understandings suggested within the history education field itself.

3. 9. April as a dual scaffold for counterfactual thinking

In *the dilemma game 9. April 1940*, players are placed in the shoes of Danish Prime Minister Thorvald Stauning in the days of the German invasion one spring morning in 1940. The point of the game: to give players a sense of counterfactual historical thinking.

Military and diplomatic options were available to Stauning at several junctions, including to what degree military defenses should be mobilized against the superior Nazi war machine, diplomatic responses after the inevitable loss, and options for a new government that would be acceptable to both German and Danish interests. The game interface itself is designed as a simple hypertext site, where each page includes a heading (e.g. *April 8. in the evening. German forces moving on the border!*) date and time (e.g. *April 8. 1940, 20:00*), text describing Stauning's situation (including his location if players opt to evacuate the houses of government or flee to Sweden), a historical photo, and two to four options (e.g. *1. An arrangement with Germany?, 2. Bide your time, 3. Send troops to the border, 4. Prepare everything!*). In addition, four advisors (members of your cabinet, opposed Danish politicians, the King, military officers, etc.) are available to voice their opinions. Finally, at the top right of the screen, meters count casualties on each side, dead civilians, your relationship with Germany and the Allies respectively, and the nation's inner coherence as the game progresses.

Making a choice will lead the player to a new time point, with new dilemmas, until you are either deposed or manage to settle Denmark into a more or less harmonious relationship with the Wehrmacht. The end-screen describes Denmark's fate during the war based on the signals sent by your actions, as well as how Stauning will be remembered given these counterfactual choices.

Through the most traditional lens, the dilemma game can be seen as a deployment platform for semantic information and experience "about" the Nazi occupation, where interactive game elements mainly supply a motivational framework. For instance, the composition of the government and its relationship with e.g. the Danish Nazi leader Fritz Hansen is realistically depicted until players actions change things, as is the evacuation plans to Høvelte military base north of Copenhagen. The game has been framed as an authoritative source for potential counterfactual scenarios written by national experts (Lieberoth & Brunbech 2015) so students could be worse off than referencing these visions of what might have happened even if they do not manage to metacognize clearly in terms of second-order concepts. This first-order content scaffolding facilitates interaction (as per Lund 2012) with second-order phenomena.

The procedural nature of the choice-tree gameplay places second-order concepts like if-then thinking, branching and causality front and center in the experience. In terms of 21st century skills, exploring the game's possibility space is an exercise in domain-specific but conceptually transferable systems thinking. These concepts are implicitly experienced though play, but may require some teacher mitigation for consolidation into more explicit knowledge and generalizable metacognitive understanding to happen (Lieberoth 2013; Moon 2004; Kolb & Kolb 2008).

According to transformative learning theory (Mezirow 1997), good learning cannot be equated with assimilation of information into a static store. Rather, learning trajectories are seen as continuous perspective transformation in-and-for meetings with the world. In this view, half the point of taking part in an activity like playing *9. April* is to first experience procedural logics of choice and causality (see also Bogost 2008), and then - either though personal reflection, the game or pedagogies surrounding it - to consolidate dawning implicit competences into explicit understanding (Lieberoth 2013) and new cognitive habits.

Figure 1: GUI in a choice scenario from April 9. (www.9april1940.dk)

Accordingly, the notion of transformative play (Barab, Gresalfi & Arici 2010; Barab, Gresalfi & Ingram-goble 2010) holds that a good game for transformational learning is *"a place where the actions of a ten-year old can have significant impact on the world; and a place in which what you know is directly related to what you are able to do and, ultimately, who you become"* (Barab n.d.). The knowledge needed to enter the transformative thinking process may however, sometimes be lacking, as may starting points for systematic thinking patterns. In this light, *April 9th* can be viewed as a dual scaffolding (as per Wood et al. 1976) for counterfactual history thinking in terms of both the background knowledge needed to think meaningfully with-and-about circumstances surrounding the Nazi occupation, and structuring the parameters for counterfactual thinking such as bounded choices and evaluation parameters: A *dual scaffolding* supporting both first-order *and* second-order competences needed to develop and exercise the thinking skills in question.

Games have numerous characteristics beyond branching narratives, notably related to variable outcomes and properties of game states (Juul 2005). Seeking optimal strategies through multiple playthroughs may lead to insights about the logics used by historians to conceptualize the game's procedural framework: In this case a war history seen through the eyes of a real decision maker with several significant choice junctions accompanied by direct results opening and closing of other opportunities. This procedural view, as it were, is a legitimate way of conceptualizing and talking about history in second-order terms. Thus, "playing around" and "gaming the system" by considering its logics and exploring its possibilities can be seen as exercising lauded 21st century skills in addition to simply appropriating new ideas or faithfully adapting one's knowledge structures according to them (as supposed by Piaget 1974).

Given this breadth of considerations from first-order knowledge to attitudes and second-order thinking skills, it really only makes sense to explore a wide spectrum of effect parameters for the effects of the dilemma game.

4. Method

We had four classes play though the dilemma game three times, with quizzes before and after along with self-reported statements designed to gauge attitudes and modes of thinking with-and-about history. Potential predictors of change to these, like engagement and play style, were probed just after. As such, each measure represents a casual hypothesis, but no particular null hypotheses were formulated.

4.1 Participants

106 Danish students, 59 female and 47 male, from four different 8th and 12th grade classes age 14-19 (mean age 16.01) were enrolled in the study by their teacher. Few significant differences were found between grade levels in the data, so the entire population is treated as one cohort for the present more explorative analysis.

The average participant reported playing digital games on a weekly basis, with some never playing and some every day. They believed themselves to have "some" knowledge of history on a 1-5 likert scale (M = 3.08, SD = .70), and a little less about Denmark during the Second World War (M = 2.82, SD = .71). They reported middling average interest in the subject (M = 3.09, SD = 1.13).

4.1.1 Materials and procedure

Before play, students supplied background information (age, gender, school, class, gaming habits) via the online platform SurveyXact, and marked off level of agreement with a series of attitude statements about history as a subject, historical thinking and WWII on 1-5 likert scales.

Students were then given a quiz consisting of 24 binary statements about historical facts, ranging from whether Stauning is an actual historical person to Germany's reasons for invading. Answers had to be given on in terms of both "true" or "false" and three levels of confidence extending from a "don't know" middle, thus creating a 7-point scale (accuracy α = .674).

The survey then sent participants on to www.9april1940.dk, instructing them to play three times, each time recording the counterfactual ending they reached (not analyzed here). After three playthroughs they were asked to what extent five different strategies reflected their play-style:

"When I played…"

- I mostly just looked at the options available
- I checked the advisors on the right when making my choices
- First and foremost, I read the text to find consequences of my actions
- When playing the second and third time, I consciously went for "wilder" outcomes – e.g. more casualties
- I checked the numbers for casualties and diplomatic relations in conjunction with my choices.

Standardized measures of interest/enjoyment α = .862, value/usefulness α = .887 (Intrinsic Motivation Inventory 1994; Ryan & Deci 2000; trans Lieberoth 2015), and transportation into fiction α = .664 (Green & Brock 2000) were then administered, followed by a reprise of the quizzes and attitude statements. Item sequences were randomized for counterbalancing.

5. Results

5.1 Effects after three playthroughs

Before play, the students answered an average 9.23 out of the 24 questions correctly (SD = 3.84, Range 0-21), and reported a mean confidence of 1.11 (SD = .50, range 0-2.5) on the scale from 1-3. "Don't know" counted for zero. After play, accuracy rose to 11.18 (SD = 4.67, range 0-20) and confidence to 2.96 (SD = 1.43, range 0-2.96). This makes for an average gain of 1.91 correct items and .31 confidence. The changes ranged from -11 to 14 suggesting that some students answered pretty much at random, at least in the post-test.

An ANOVA *F*-test revealed that the increases in the percentage of correct answers, F (1, 101) = 20.62, $p < .001$, $\eta_p^2 = .17$ and confidence, F (1, 101) = 32.44, $p < .001$, $\eta_p^2 = .24$ were statistically significant.

Students also rated their general knowledge about Denmark during World War II as higher after play, F (1, 101) = 7.61, $p < .007$, $\eta_p^2 = .07$

Students also increased their beliefs that Danish soldiers were abandoned by their political leaders during the invasion *F* (1, 101) = 3.58, $p < .06$, , $\eta_p{}^2 = .03$ (a tiny effect), and that the politicians found themselves in a very difficult situation on April 9th 1940, *F* (1 , 101) = 18.71, $p < .001$, $\eta_p{}^2 = .16$, which could together be taken as an indication of increased historical empathy.

5.2 Predictors of learning effects

A bivariate correlation matrix was generated to identify predictors for the changes identified by the initial ANOVA-analysis.

Improvements in quiz performance and confidence were highly correlated, *r* = .672**, and to a lesser degree with students' evaluation of their WWII-knowledge *r* = 213* - .279*.

Both performance and confidence increases had small correlations with the amount of text read during the game, *r* = .239*-248*, and small negative correlations with perceived value/usefulness, *r* = -.261**- -.267**.

Increases in students' evaluation of their WWII-knowledge likewise correlated the amount of text read *r* = .201*. Interestingly, and perhaps sadly, this was also negatively correlated with interest/enjoyment (the main measure of intrinsic motivation), - .239*, value/usefulness, *r* = - .203*, and transportation into fiction, *r* = - .225*.

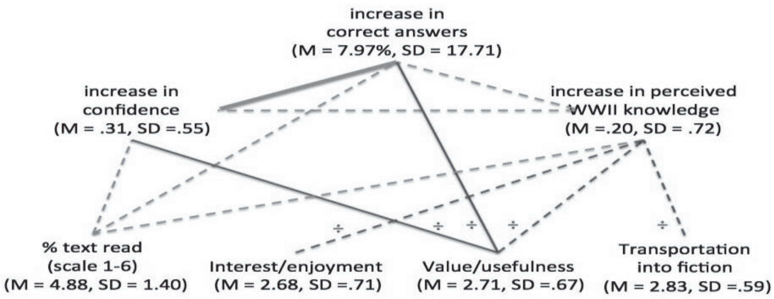

Figure 2: Correlation web of predictors of substantive/first-order learning effects

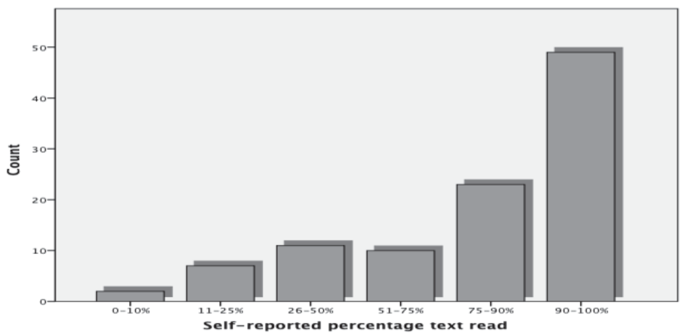

Figure 3: Many students reported reading a very high percentage of the game text

5.3 Predictors of motivation, immersion and play style

Correlations of play strategies, intrinsic motivation variables and transportation into fiction were then calculated to paint a richer picture of the play experience. Since no appreciable changes were measured in most of the attitude statements, pre-play scores were used for this analysis.

Interest enjoyment, value/usefulness and transportation into fiction were highly correlated, *r* = .544-635**, but all three were also found to be negatively related to the amount of text read, *r* = -271-442**. In addition, value/usefulness was negatively correlated with the statement *history is important to understanding present times*, -.227*. Transportation into fiction and interest/enjoyment also correlated negatively with the notion that *Danish soldiers were left in the lurch by the politicians on April 9th*, -232-3*. No other factors were found to have impacted the experience-measures.

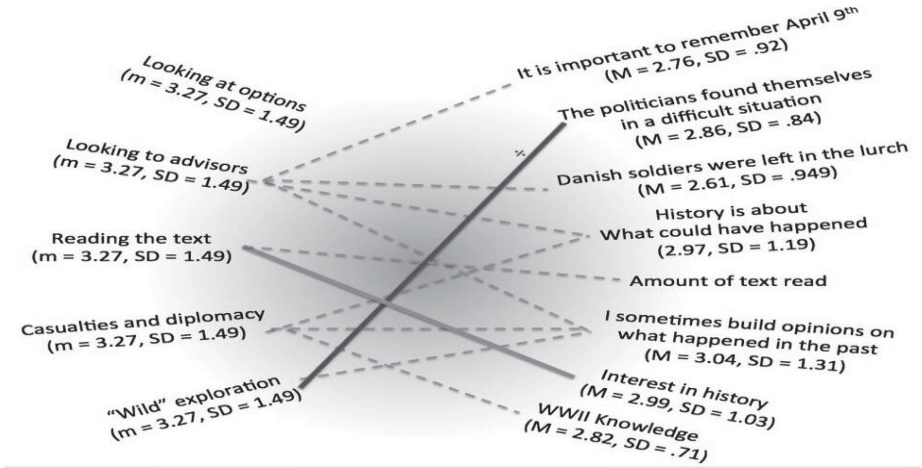

Figure 4: Correlation web of the five play styles' relationship with other factors

I mostly just looked at the options available was the most highly reported play style (M = 3.27, SD = 1.49). Perhaps for this reason it did not correlate especially with any other variable.

Looking to the advisors, on the other hand, was correlated with several initial attitudes, namely that it *is important to remember April 9th*, *r* = .233*, and *Danish soldiers were left in the lurch, r =* .233*, in addition to (and perhaps more interesting) indicators of second-order thinking that *history is about imagining what could have happened* .195*, and *I sometimes build opinions on things that happened in the past, r* = .242*.

Not surprisingly, using the text to orient oneself was related to the amount of text read, *r* = 219*, and history interest *r* = 348**.

Playing based on number of casualties and diplomatic relations was related to existing knowledge about WWII, *r* = .195*, and agreeing that *history is about imagining what could have happened, r* = .204* and *I sometimes build opinions on things that happened in the past r* = .233*.

Going for progressively "wilder" results in the three playthroughs was the least reported play style (M = 2.63, SD = 1.37). It correlated only with *sometimes I build opinions on things that happened in the past*, *r* = 198*. Finally, a negative correlation, *r* = -.317**, was found between increased empathy with the politicians' difficult situation and having moved through the three playthoughs in a "wild" explorative fashion.

6. Discussion

This paper has presented the immediate effects of 106 students experiencing the dilemma game *9. April* in terms of attitudes, insights and factual knowledge, as well as predictors for these changes. Perhaps most interestingly, students appeared to develop their sense of historical empathy with both politicians and soldiers – a trait which was also predicted by adapting a play style that involved looking to the other historical characters available for advice.

Benchmarked against the interventions in Hattie's massive metaanalysis of education effects (Hattie 2008; Lieberoth et al. 2015), playing the game had the same immediate impact (small-to-medium effect sizes as per Cohen 1988) on quiz performance and confidence as time spent with a teacher. As such, playing would appear to be no better or worse than any other lesson. A glance at frequency tables for the quiz items, however, reveals that the average quiz performance fell below chance level due to "I don't know" answers counting for zero. Perhaps we would have become wiser about students' intuitions had we forced a choice instead of allowing these non-answers. An important angle to remember when evaluating single-experience results is also that games like April 9th are pre-packed with a *particular* set of learning opportunities which students may not otherwise have been afforded, in this case experiences with difficult second-order competences like counterfactual historical thinking and empathy.

Disappointingly, our wide cloud of buckshot-factors identified few changes in students' views, and none in thinking of history as being "about imagining what *could* have happened" versus "about things that *happened* in the past". As such it does not look like most students' attitudes shifted from a first-order view focused on substantive content to a procedural second-order view of history as a subject that can also involve counterfactual reasoning and reflection on phenomena like change and significance - in short, 21st century thinking skills. Given how many variables were fed into the exploration the chance of type one errors is also quite high – that is, at the 95% confidence level it is even statistically likely that one in 20 findings simply reflect random noise in the data. As such we should take the many results with lower statistical significances or small effect sizes ($r < .30$ and $\eta_p^2 < .25$, according to Cohen, 1988), as well as those that lack immediate theoretical sense, with a grain of salt.

Different play styles were dissociable in terms of correlations with other variables, which demonstrates that we successfully probed separate approaches to the game. It looks like checking one's options was a universal, while using the historical characters available to look for advice was correlated with second-order historical sensibilities, including a sense of historical empathy and understanding that counterfactual scenarios can be part of historical thinking. "Wild" explorations like looking for maximal carnage, on the other hand, appears disjointed from any relationship with history perhaps revealing a gamer's mindset rather than a learner's, including lacking empathy with the historical characters. It also looks like reading a lot of text was a viable, if boring, strategy for learning a lot from the game, but mainly at a substantive level rather than for building second-order thinking skills. If accurate, the high percentage of text reading reported also suggests that the majority of students approached *9. Apri*l as a conventional information-oriented online exercise rather than an opportunity to procedurally experiment with counterfactual scenarios and the related suite of thinking skills.

Even though we have framed the game as a dual scaffold for both first- and second-order historical competences, with one supporting the other, students own mindsets and teacher uses may have placed focus on the former. It is interesting to note how students were able to consciously register their learning in terms of confidence and increased subjective WWII knowledge, but also how the latter was negatively related to the measures of intrinsic motivation and transportation into fiction. This finding mirrors other work using these exact measures (Lieberoth, in prep; Lieberoth & Roepstorff 2015), perhaps revealing that the students who stand to gain the most are often least engaged, or that those who work hard to learn are also more critically inclined toward nontraditional learning experiences that are more difficult to translate into directly perceived "exam grade utility". The latter is a sad reflection of the mindset ingrained into students by the institutional realities of school, and a challenge to teaching "less gradable" 21st skills that are extremely important to a young person's success in life beyond school.

7. Future directions

The goal of this paper was to seek out relationships between factors for the next (longitudinal) steps of our research. As revealing and fun as correlation matrixes can be, they are uninformative about causality or the deeper relationships between variables. To understand such issues, a study needs more specific hypotheses, which are usually formulated through exploratory examinations using a wide net of variables like we have done here. This step is sometimes taken as a necessary but basic interlude, and not reported much on, even though the story can be quite interesting and give other researchers a look behind the quantitative process. This paper was a viable exercise in correlational data analysis, but we look forward to probing the deeper relationships, such as mediation, hinted by the correlation webs in figure 2 and 4. It will also be very informative to see whether different play styles also lead to different, for instance more extreme for the "wild style", game endings, and if this somehow correlates with learning outcomes.

A palpable limitation discovered here, was the difficulty of measuring second-order thinking, which is a preferable conclusion to the possibility that none occurred. We view this as a challenge that should be considered early in the game – not research – design stages, as we plan the learning trajectories with accompanying effect assessment for new dilemma games.

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Haunted: Intercultural Communication Training via Information Gaps in a Cooperative Virtual Reality

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Abstract: In our paper, we present a novel way of oral language training, as well as vocabulary training for students and teachers of English as a Foreign Language (EFL) by embedding the language learning process into a generic 3D Cooperative Virtual Reality (VR) Game. The game is designed for students of different countries, training their Intercultural Communicative Competence (ICC) as well as helping them to overcome their insecurity in speaking without losing their faces. It is therefore necessary to create a most comfortable atmosphere to interact in a second language. Especially when the circumstances only allow conferences via video or phone, the learners are rarely induced to use words and phrases intrinsically. Our approach follows current research's demand for integrating creative tasks and alternative language learning schemes. It evokes communication between two players by implementing information gaps in a VR game, which makes information exchange necessary to complete the tasks and win the game. We therefore propose a game design template that is focused on creating a high density of information gaps by giving the players mutually exclusive abilities and different perception of the environment. From the template, we derive a game in which two players take the roles of a human and a ghost within an everyday environment. Their aim is to chase away Non-Player-Characters (NPCs), guarding items. It is our generic concept to arrange individual "atmospheres of fear" for the NPCs, who are each afraid of different everyday objects. Hence, the game can be extended by adding further subjects of learning in form of items and objects, depending on the need of learners and teachers. We analyzed the possibility to incorporate a given curriculum into our VR game. Therefore, we created a game content based on the curriculum obtained by the Graded Examination in Spoken English (GESE) Trinity Exam, a widely recognized test in international schools and universities. The empirical analysis of the communication among 26 test persons of different mother tongues shows that our game evokes a high amount of speech and a qualitative linguistic outcome that covers the requirements of the curriculum. In course of the game, the students train their listening, speaking and reading skills, as well as ICC. Thereby, they become more confident in using English as Lingua Franca.

Keywords: second language training, virtual reality, English as Lingua Franca, cooperative learning, information gaps, generic gameplay

1. Introduction

Speaking practice is an important aspect of foreign language learning. In school, language learners are not able to practice their communicative competence satisfactorily: According to a study, a usual lesson is too short for every learner to practice speaking sufficiently (German Institute for International Educational Research 2006). Although the language classroom utilizes a variety of different methods, it is still very limited in its possibilities of promoting authentic communication skills as the situation as such is not authentic: the students' ambition to speak English is extrinsically motivated . This problem can be solved within VR, which simulates real life situations to create an authentic language training environment. This is useful especially when external factors do not allow an appropriate covering of the topic. Here, avatars help to overcome the differences of time and location. Lan, Lin & Kan (2012) pointed out that "there is a need to focus more on any creative task design and innovative language teaching formats in such environments (e.g. [...] information gap [...])" (77). We concentrated on this particular call and investigated how to induce a VR setting with information gaps, a sophisticated, communication invoking method. To elicit this intrinsic language usage, everyday life situations need to be simulated. Furthermore, these situations are improved as they provide a safe environment, in which learners are allowed to make mistakes without losing their faces. They can train their speaking skills in these situations and gain the confidence they need to communicate successfully in the real world.

Our central contribution is to answer the question if intrinsically evoked language within a VR can correlate with the language requirements of a given curriculum and if this method is consequently suitable for authentic language acquisition and training.

We therefore propose a game design template that creates a high density of information gaps in a virtual environment and describe the generic game design with focus on the communicative output. By adding parts of the GESE curriculum, created to test the learners' speaking and listening skills, we implemented the language training game *Haunted.* It promotes language learning and practice due to the necessity of communication intrinsically evoked by information gaps in order to succeed. The intrinsic language usage is increased by simulating everyday life environment without the threat of losing their faces during language practice.

Our paper is structured as follows: firstly, we give a short overview of the benefit of computer games for the purpose of learning and training a Lingua Franca, especially concerning the added value of a VR and the possibility to simulate a real life setting. From our argumentation we derive a design template which is exemplary instantiated in chapter 4 by introducing the game *Haunted* that reflects the content of the GESE curriculum. The intrinsically motivated communicative output and its qualitative and quantitative linguistic outcome observed among 26 test persons is described in chapter 5 and 6. In chapter 7, we discuss our findings with respect to our solution's chances and challenges and the suitability for its usage within English lessons.

1.1 Theoretical framework

The Task-Based Language Learning (TBLL) approach is a commonly used approach in EFL learning: It concentrates on the *content* and the *meaning* rather than the production of the correct linguistic outcome (Hall 2011: 96) and can be adapted according to the need of the learner and the curriculum. This encouragement of spontaneous language usage enables students to move out of their comfort zone and is therefore considered good preparation for real-world experiences (Willis 1996). By language acquisition through meaningful content, learning and training becomes more effective: Students retain knowledge from the game longer than by finishing exercises. Thus, the motivation of completing a game and cooperating with natives or foreigners promotes both learning and memorizing (Hubbard 2009: 2). Furthermore, different language skills can be promoted by making use of several beneficial aspects of the Computer-Assisted Language Learning (CALL) approach and Communicative Language Teaching (CLT).

CLT is vital for each language learning environment, as it "focuses on the meaning potential of language, i.e. in language use, and it stresses the social aspects of that context" (Müller-Hartmann & Schocker-v. Ditfurth 2009: 20). Language learning is most successful in communication as the learner has to combine language skills. However, many learners do not seize the chance of practicing in the language classroom due to time reasons or introversion, which results in them remaining silent. Therefore, a neutral and private learning atmosphere should be created according to the learners' needs.

2. Related work

Many language researchers, including Blake (2008), Hall, Byran and Hu, agree with Michael Evans claiming that "language teaching and learning, at all levels, can benefit from the mediation of technology" (Evans 2009: 28). It is their overall viewpoint that new technologies are of vital importance for the EFL classroom.

Studies in England from Vanessa Pittard et al. (2003) found a connection between the use of technology in classroom and students' motivation, although neither VR nor any other electronic devices can replace the teacher. Rather, a hybrid learning format could enhance language learning if used appropriately.

Chen et al. (2012) did a survey among pre-service teachers of a computer-assisted language learning course by having students play a commercial adventure game containing the exploration of a 3D environment. The teachers showed very positive attitudes towards the video game, observing that video games can be very useful for vocabulary, listening and reading skills, and the enhancement of students' logical thinking and reasoning abilities. However, the teachers analyzed that a single player game is limited in promoting speaking and writing skills within a virtual 3D world. Therefore, collaborative learning and oral language training within a multi-user VR is a preferable approach of which many examples exist: Studies conducted by Wang et al. (2012) showed that "Second Life was highly motivating and effective in facilitating EFL learning" among Chinese students. In addition, Chittaro and Ranon (2007) state that the use of multi-user VR environments provide learners with various learning experiences, which appear to be difficult to offer in real world scenarios due to distance, time, cost, danger or impracticality. This is particularly valuable for EFL language learning (Wang et al. 2012). Furthermore, other studies have shown that multi-user VR environments successfully motivate participants to learn (Barab et al. 2005, De Lucia et al. 2009).

Wang et al. (2012) summarized that multi-user VR learning platforms have to offer four distinct features: A 3D illustration space, an avatar that visually represents the user, interactive tools for multimodal communication (Dickey 2005, Dickey 2011) and the ability to interact with the world (Hew & Cheung 2008). For the special purpose of oral language training, methods for generating speaking incentives can be added as a further requirement.

One example is "A collaborative virtual environment for situated language learning using VEC3D" by Sish & Yang (2008). In contrast to a freely explorable open world, they used a goal based scenario practicing open-ended role-playing of real life situations.

In their content analysis, Lan, Lin & Kan (2012) conducted the results of 23 articles about language learning in VR. In conclusion, they point out that the effectiveness of language learning can be increased with VR but there was still a need for further research on task design, serving the purpose of generating speaking incentives. This inspired us to generate a template for schematically designing tasks in a collaborative setup that offer a high density of information gaps. In contrast to Sish & Yang's free role-play approach, we decided the goal not to be open-ended but to be defined by fixed game rules and tasks, which are comparable to a conventional adventure game used by Chen et al. (2012).

2.1 Added value using VR for language learning

VR environments are "experimental and intuitive. It is a shared information context that offers a unique interactivity and can be configured for individual learning and performance styles" (Bricken 1991: 178). Since VR is a simulation, it provides a safe environment where learners are allowed to make mistakes without losing their faces. A VR can depict a realistic world with visual and aural representation of everyday life: Persons, objects and weather can follow the same rules as in real life. Unlike common learning material, "the VR learning environment is a context that includes the multiple nature of human intelligence: Verbal/linguistic, logical/mathematical, auditory, spatial, kinesthetic, interpersonal and intrapersonal" (Bricken 1991: 179). Thus, the learner forgets that this is still a learning environment, which is why the language output is motivated intrinsically. This factor is of vital importance when it comes to conceptualizing tasks due to the fact that syllogisms solving the tasks and leading to further action planning do not necessarily have to be part of the defined and limited rules of the game. These 'principles of life' consequently offer numerous opportunities of action and complex characteristics of objects without the necessity of any kinds of explanation. The embodiment within VR additionally seems to promote a natural learning process: If I grab, hold and possess an object, I am more likely to imprint this than by simply looking at a picture of the corresponding object. The same goes for language competences. By navigating someone through VR, one is much more likely to train his navigation skills than by the mere description on worksheets. Furthermore, the coherence within a collaborative VR is given much more than in other learning environments with fictional content: Due to the fact that both players are set in the exact same world, misunderstandings occur rarely. However, while realism should predominate in VR, the creative process of designing a game demands specific rules which differ from reality and thus need to be explained to the players.

3. A template for generating information gaps

A mere replication of reality does not serve any methodological advantage compared to a real environment as domain of speech, as no further stimuli to speak are evoked. It is therefore essential to include an aim and the necessity to cooperate with a communication partner, which motivates language usage. This can be achieved by creating tasks whose solution requires cooperation based on information gaps: One language partner has knowledge of certain aspects which the other one has not, but which he needs in order to solve the task.

Generalizing the rules of the game simplifies the fulfilling of given requirements in terms of content. Information gaps can be generated according to the following scheme: One part of the required information is presented to player B, keeping it invisible to player A. But partner A is the only one who is able to perform this certain action in order to receive the second part of the information. Accordingly, player B has to communicate his information so that A is able to act according to this input and thereby unlock the next task. Now player A is able to perceive a certain information which is relevant for an action only player B is able to perform. Consequently, the game cannot be won without communication and cooperative acting.

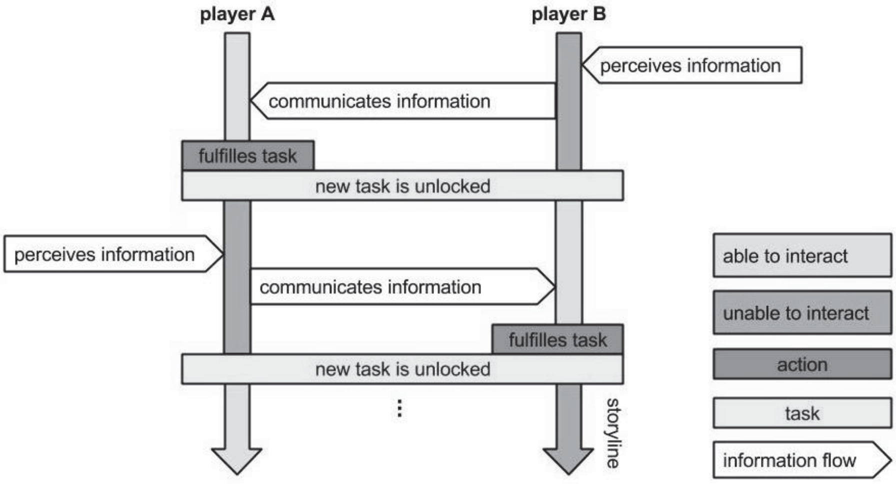

Figure 1: Our design template for a collaborative two player game aims at a high density of information gaps

3.1 Application of the template

The Trinity College London is a fully accredited international exam board. The GESE provides a curriculum, based on the Common European Framework, decisive for the curricula of most European schools. GESEs are oral one-to-one, face-to-face interviews that "test the English speaking and listening skills of people whose first language is not English. They focus on building motivation and confidence in using English [...]." (Trinity College London 2014). The exam's requirements are summarized as follows: Language Functions, Grammar, Lexis and Phonology. Our training game is suitable for basic language users, covering fundamental language functions. These are henceforth noted as "Language Requirement 1" (LR1), such as giving simple directions and locations, indicating the position of people and objects, describing people, animals, objects and places and stating simple facts. The grammatical language requirements (LR2) include can't and can, prepositions of movement, place and time, link words, determiners, present simple tense and questions. The lexis in our game covers rooms in the house, household objects, pets, cardinal numbers and weather (LR3). It is important to acknowledge this game as a training for the GESE. New vocabulary, phrases or grammar are not intended to be acquired while playing.

This game serves as the third stage of three overall training levels: firstly, students train individually, fostering their knowledge on the corresponding language fields. In the second stage, they play competitively. Our game is the third stage which is a collaborative level, enabling the learners to train the language fields of the first two stages within communications and thus promoting communicative competence.

4. Game design

The training game Haunted is designed for two players having to communicate in order to win it. It is embedded in a scenario which is explained and depicted in an introductory video, combined with a tutorial sequence: Jimmy forgot to lock the front door, which is why many strangers, implemented as non-player characters (NPCs), squat the mansion. Jimmy's ancestor appears as a ghost who is able to banish all the strangers if some magic items are collected.

The estate consists of a garden and a mansion composed of two floors (see Figure 2), each of them has 8 named rooms (e.g. bathroom: R17). They are furnished with common housing objects like cutlery in the kitchen, towels in the bathroom, etc. to support the logical transaction, vocabulary acquisition and to help the players to orientate themselves (LR1, 2, 3). Since Haunted is based on the template from 3.2, the two players are lacking essential information they need to complete a task (see Figure 3). One player, representing the human, can interact with the environment and pick up objects (see Figure 4a). Contrastingly, the player representing the ghost is not able to move objects. Nevertheless, he knows which items have to be found to win. For orientation both players can look at a map of the mansion.

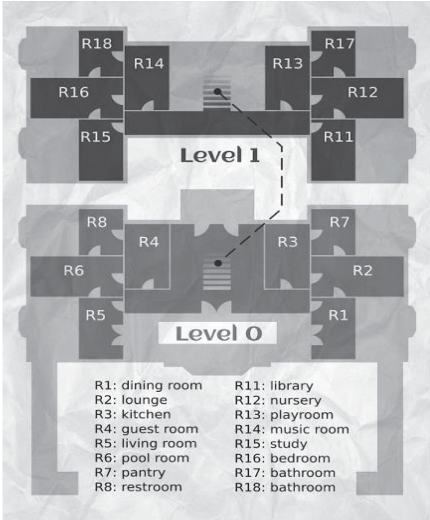

Figure 2: A map of the house with named rooms

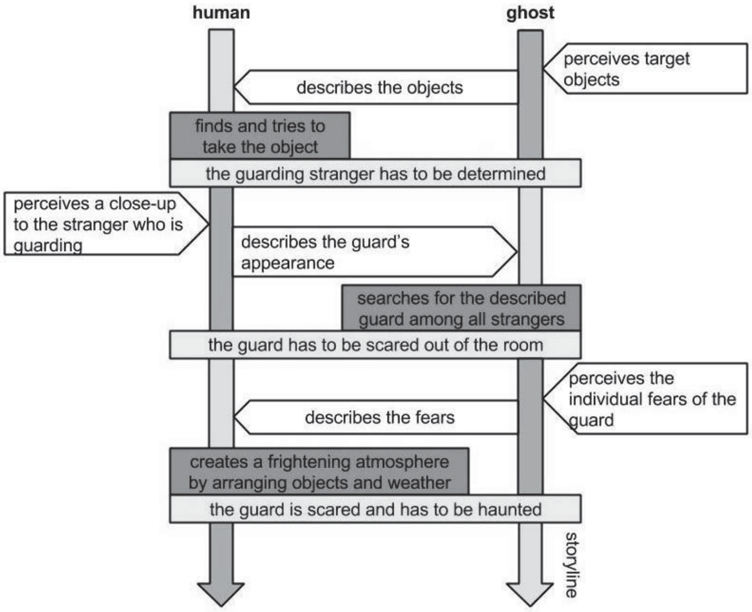

Figure 3: Concretization of the abstract template for the game *Haunted*

In some rooms these items are guarded by an NPC, who has to be scared away by the ghost in order to let the human pick them up. However, there are always a couple of NPCs staying inside the room where a desired item is placed. These NPCs look randomly different, namely in terms of the color of their clothes, their eye color, their skin color and the shape of their faces. Since only the human player perceives a close-up picture of the one guard among all NPCs, he has to describe the correct NPC's appearance (LR1) to let the ghost do his work, which requires only one more thing: a scary atmosphere. The ghost can read all the NPC's individual fears, depicted above their heads (see Figure 4b). If the ghost describes the fears of the correct guarding NPC (LR2,3), the human can arrange that NPC's scary atmosphere. This consists of certain items and/or a specific weather condition (see Figure 4c). The weather can be changed by the human by clicking on a magic picture (LR3). Since droll fears can be irrational, the requirements can be generically replaced by any conditions and objects, like even a fork, sunshine or a model car. This enables the game to cover a large amount of fields of words without the need of further implementation. Also, via nesting the tasks, the game can become arbitrarily complex and time-consuming by letting a scary item for one NPC be guarded by another NPC.

The algorithm that shuffles the NPCs and fears ensures that the game remains solvable and does not exceed a maximum complexity. Due to our generic concept, the game content can be expanded by placing further objects into the house or add further characteristics to the NPCs.

Haunted was developed by using Unreal Engine 4 which enables realistic graphics, a physical interaction, computer-controlled NPCs and extendible content. We implemented functionality to use head mounted displays and motion controls. Both were successfully tested with Haunted to enhance the immersion. To simplify testing, however, we did not use such devices within the evaluation process due to the influence of motion sickness and of unusual input devices.

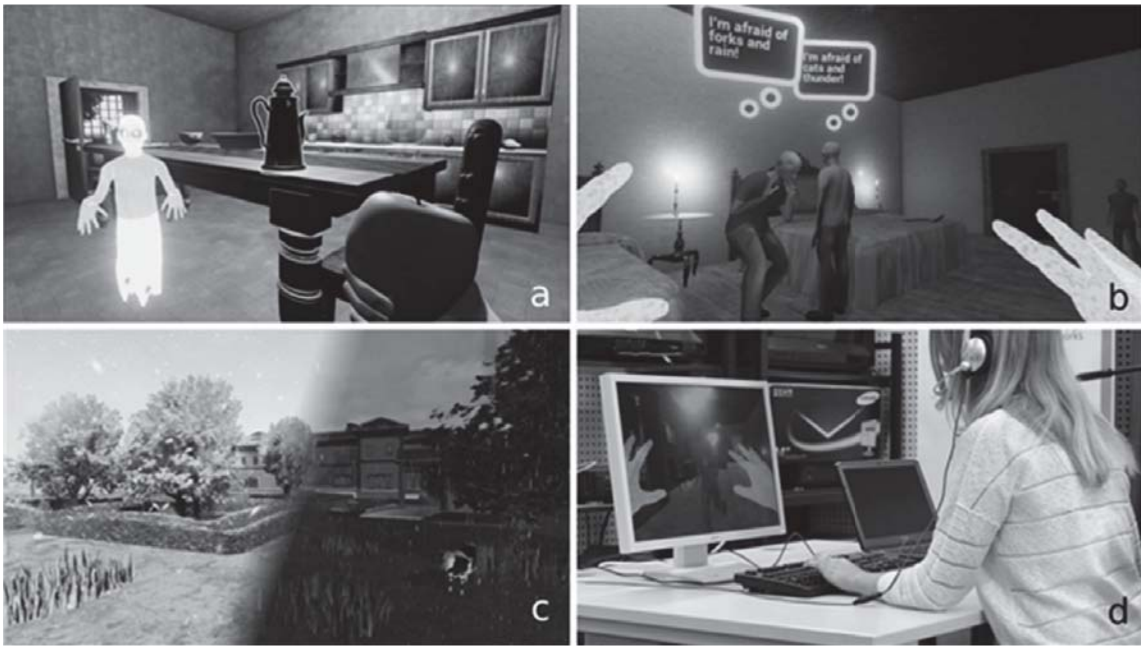

Figure 4: a) The human's view as he holds an apple. The kitchen is stuffed with typical objects. b) The ghost's view as he reads the fears of the NPCs. c) Two different weather conditions. d) A participant of our user study

5. Evaluation design

We designed an evaluation setup in which the players have to collect three fixed winning items from the pool of selected vocabulary (see Figure 4d). To guarantee an undisturbed and quiet test environment, we took an evaluation laboratory where we observed them as a third invisible spectator. The evaluation was conducted with 26 participants (7 female, 19 male) in total, who were between 12 and 34 years old (mean = 23.64, SD = 4.70). We shuffled the participants within the two player groups in a way that most of the time both players did not share the same mother tongue, which required using English as Lingua Franca to communicate. Within all participants, the self-estimated English knowledge had a medium value of 4.48 (SD = 1.16). Here, a likert-score of 1 means little English knowledge and 7 refers to mother tongue.

We divided the evaluation into three phases: introduction, observation & motivation measurement, and feedback. Within the introduction phase, the participants were distributed to the two computers. After that, the first part of a questionnaire was filled in which includes some preliminary questions. It is worth mentioning that the game was played at normal pace. i.e., there was no instruction given like collecting all winning items as fast as possible. After the fulfillment of the first questionnaire, an introduction video was shown to familiarize the participants with all features and the gameplay mechanics of the game. Subsequently to the introduction phase, the participants played the game to find all three winning items. As soon as the participants collected the first winning item, a questionnaire to assess current motivation in learning situations (QCM) (Rheinberg 2001) was conducted.

The QCM uses items to measure four motivational factors: anxiety, probability of success, interest, and challenge. Thereafter the game was continued normally. As soon as the goal of the game was reached, the participants completed the questionnaire in the feedback phase with some additional questions and qualitative feedback.

6. Evaluation and results

During the evaluation, we gathered measurements for the players' satisfaction and asked general questions through the questionnaire. Each question was answered on a visual analogue scale (Reips 2008), which ranges from strongly disagree to strongly agree. However, we translated the obtained values to a standard Likert scale for reasons of comparability and presentation where 1 means predominantly disagree and 7 refers to predominantly agree. Furthermore, we measured the current motivation of the players, after they collected the first winning item, using the QCM with the same standard Likert scale. Subsequently to all questions, we also asked for games where the players communicate less, equal, or more than in Haunted and we gave space for free comments and suggestions. Details on all questions are provided in section 5. In addition to these measurements, we transcribed all conversations within the game and categorized the speech.

6.1 Attitude towards the game

We analyzed the results from the QCM by using a confirmatory factorial analysis to see if we can reproduce the four dimensions created by (Rheinberg 2001) namely: probability of success (e.g. "I think everybody can manage this task"), interest (e.g. "I don't need any rewards for tasks like this to have fun"), challenge (e.g. "I am very eager to see how I'll manage this task"), and anxiety (e.g. "I am afraid of making a fool of myself"). Thereby, we removed some items because they loaded on other factors, leading to a total of 11 items. The four components hold an eigenvalue greater than one and all together they accounted for 73.59% of the variance. The factor loadings of the remaining items varied from 0.50 to 0.85. Cronbach's alpha for the components were 0.76, 0.65, 0.73, and 0.65. As seen in Figure 5, the participants, except one outlier, estimated their probability of success being good, as the high mean likert-score of 5.9 (SD = 0.84) implies. Furthermore, they feel the challenge being highly enthusiastic, as depicted in the high mean likert-score of 5.02 (SD = 1.14). Due to the fact that, according to Sprenger, motivation is generated by a challenge and a realistic probability of success (Sprenger 2014: 10), our game can be classified as motivating. Theorists such as (Krapp 1998), (Schiefele, Haußer & Schneider 1979) claim that voluntariness of task solving occurs corresponding to the interest. The high mean likert-score of 5.1 (SD = 1.03) shows that the participants are interested in playing Haunted. Even though the participants used English as Lingua Franca, the low mean likert-score of 3.3 (SD = 1.53) shows that they were not too anxious about playing the game while communicating in a Lingua Franca. This evaluation proved that playing Haunted is both motivating and interesting for language learners. Consequently, we can assume that it contributes to a comfortable learning atmosphere.

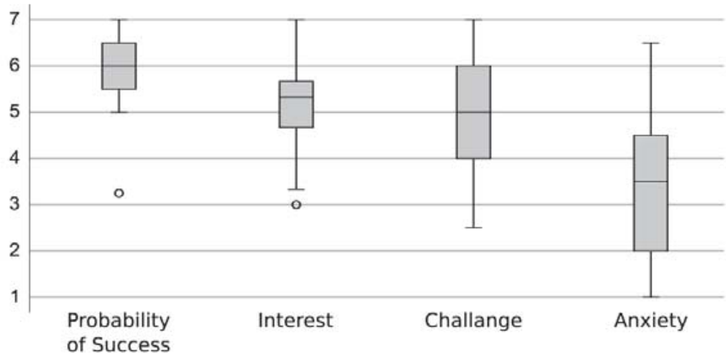

Figure 5: Boxplots of the four extracted QCM components. A high value means predominantly agreement

In addition to the QCM, the questionnaire from the evaluation feedback phase revealed additional information of the participants' opinions and feelings about the game. For instance, the high likert-score of 6.44, SD = 0.82 of the question "during the game, I communicated a lot with the other player" and the low likert-score of 1.36, SD = 2.66 of the question "we could have solved the game without communication" shows that Haunted stimulates communication between the players. Furthermore, the game was neither too easy nor too difficult as a likert-score of 4 implies. Beyond this, we could find a strong, significant correlation (r = 0.702, p = 0.000) between the question "the game was intuitive" (Mean = 5.52, SD = 2.51) and the question "the game can motivate language learning" (Mean = 5.64, SD = 1.40). However, the high standard deviation of "the game was intuitive" shows potential for improvement. One option could be to enhance the VR controls of Haunted appropriately.

Complementary, we found another strong, significant correlation (r = 0.585, p = 0.002) between the question “the game was entertaining” (Mean = 5.96, SD = 1.12) and the question “the game can motivate language learning.” In the case of Haunted, both correlations can indicate that the entertaining and intuitive gameplay motivated the participants for language learning.All things considered, we observed the players to be ambitious to solve the different tasks and therewith to win the game, which was expressed by positive emotional responses, e.g. laughing, applauding or exclamations (“Yeah!”, “We did it!”). In most cases, insecurities on how to solve the task at hand (e.g. searching for an item which was unexpectedly hidden in the garden instead of inside the house) led to eager communication on planning among the players instead of frustration and isolation. Moreover, we observed that solving the harder tasks was more satisfying and often accompanied with cheering and paying compliments. However, our game aimed at a high overall probability of success. In further studies, the communication depending on the difficulty level could be analyzed.

6.2 Communication quantity

In average, the participants’ speech consisted of 730.22 words (SD = 261.00) within a mean playing time of 24.61 minutes. We categorized three different phases of gameplay, the first being “Orientation”, with an amount of speech of 13,08% (SD = 5,1%). Here, the players orientate themselves and find each other in the game. Giving short instructions or asking short questions like “let’s go on” or “where are you?” also counts as this phase. The next one, called “Planning”, has an amount of speech of 37,85% (SD = 9,3%) and includes transfer of knowledge, as well as organizing the next steps. These are put into action during the “Execution” phase, which contains 49,06% of speech (SD = 9,4%). This phase also includes reading out the NPCs’ fears, giving orders and commenting while solving a task. It is vital to keep the “Orientation” phase as brief and comprehensible as possible, as the “Planning” and “Execution” phases contain most of the talking and provide a sufficient amount of information gaps as stimuli for communication and motivation.

6.3 Language quality

Haunted animated the participants to explain unknown words by paraphrasing the corresponding word (“Towel. You know, to dry yourself after your bath”) or by referring to word fields (e.g. cutlery: "Fork like spoon?"). Explaining unknown words is of high importance in language learning. These quotations show that Haunted is not only a training game, but also contains features of a learning game and promote the variation in language. To analyze this variation, the lexical density provides The lexical density can be calculated from the amount of different words divided by the amount of total words. Its mean value in spoken language in our game was 28.5%: more precisely, the highest lexical density among the players was 32,8%, whereas the lowest lexical density was 22,9%. In comparison, native speakers have a lexical density of under 40%.

The GESE Trinity Exam’s requirements were intrinsically motivated throughout the whole game. Language functions (LR1) such as giving locations (”So we have four rooms on the left on the bottom floor”), indicating positions (“I am in the lower bathroom!”), describing, e.g. animals (“A turtle is in the water”) and people (“He is the one with the big nose”) and stating simple facts (“In order to pick up the fork I need to scare another person”) occurred frequently and correctly.

Concerning the lexis (LR2), many word fields are covered and often used appropriately in the game, for example rooms in the house (“So, it should be best to go into a bathroom to look for soap.”), household objects (“So, it's a cattle, a black cattle. And it's gonna be in the kitchen, too.”), pets (“But if I were a tortoise I wouldn't be outside [by this weather].”), weather (“[...]we need rain.”) and cardinal numbers (“Bathroom... 17 and 18.”).

While some grammatical structures (LR3) were produced correctly, namely asking questions (“So, where are you?” - “Upstairs”), using can & can’t (“I can’t open doors.”) and prepositions of movement (“Turn around, I'm here”, “let's go downstairs.”), the grammatical output of others needs correction (“Did you saw the trousers?”) in order to improve these skills. Furthermore, some mistakes in pronunciation affected not only the course of the game (“bathroom“ was misunderstood for “bedroom”), but also caused the other player to imitate wrong pronunciation ([tɔ:rtu’a:z] instead of [ˈtɔː(r)təs]).

7. Conclusion and future work

We conclude that Haunted serves as a beneficial language acquisition game for training communicative skills, intrinsically motivating these GESE language requirements, which occur frequently and were produced correctly.

However, the successful completion of the game does not depend on the players' language quality. We observed that even by reducing statements to mere keywords ("upstairs!"), the game can be won, as well. Thus, it requires improvement in terms of correction of the made mistakes in grammar and pronunciation. Concerning the latter, playing Haunted with a native could motivate the non-native to imitate the correct pronunciation or be corrected by the native and thereby, increase the variation in language. Alternatively, an enhanced language recognition system is desirable. This would improve the implementation of pronunciation as a GESE requirement and thus promote the game's appropriateness for language learners. Additionally, the game could be integrated in the language classroom, for example by having the learners analyze and reflect the transcripts of their latest game in group work. As Haunted is only the third of three levels of language learning, the conceptualization of the remaining two levels would be ideal in order to complete the project. Furthermore, it would enable learners to train their skills sufficiently in VR.

The evaluation has shown that we developed an interesting, motivating 3D Cooperative VR Game, where learners can become confident in EFL by solving creative tasks in a comfortable atmosphere using English as Lingua Franca intrinsically. Haunted thus supports the common language learning due to numerous didactic chances for teaching in or through VR. Our game design template can be adapted depending on the need of learners and teachers. It includes a high density of information gaps in a cooperative virtual environment and thus enhances authentic language usage, as well as communicative, listening, speaking and reading skills. Consequently, playing the game compensates the lacking practice time in the common language classroom.

We also observed that our concept creates the necessity for the learners to leave their comfort zone in order to progress in the game by expressing themselves and communicating, as they cannot wait for other learners to answer for them. Nevertheless, they do not have to cope with the anxiety of losing their faces, which students usually do in real life situations. Rather, with this game, they can train their speaking skills in the safe environments of a VR and thus establish the confidence they need in order to communicate successfully in the real world. Additionally, we have shown that the gameplay should focus on the phases "Planning" and "Execution", as they take over most of the communication.In conclusion, we can confirm that our generic template is suitable for a game design covering the topic of language acquisition based on the requirements of a given curriculum.

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Enhancing Situational Awareness in Integrated Planning Tasks Using a Microgaming Approach

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Abstract: A lot of working environments today are very complex, and tasks are interdependent. This requires well-trained and skilled personnel. One example of such complex, interdependent system is a container terminal. A container terminal represents an important node in the multimodal transportation of goods. It connects the global sea transportation of goods with the more regional hinterland transportation, including the storage of goods within the terminal. In such a node, many operations have to be planned in order to ensure a high performance of the whole system. Planners of these operations need a good understanding of the situation, described as Situational Awareness (SA). To develop situational awareness, training activities that fit in the work processes, and relate closely to reality, are needed. In our paper, we introduce the concept of microgames as an approach to foster situational awareness and situated learning of integrated planning tasks within container terminals. The microgame used in this study is known as Yard Crane Scheduler (YCS), which was developed by a novel design approach known as game-storm, grounded in the triadic game design philosophy. Our experimental set-up includes YCS game play, a survey to measure SA, a survey to collect demographics and a post-game evaluation survey. The sessions include briefing and debriefing lectures. Test sessions were conducted with 142 participants consisting of game design students, supply chain and transportation students from Netherlands, Germany and the United States. Based on these sessions, we were able to evaluate the role of situation awareness in integrated planning activities, and the playability and usefulness of the microgame. In conclusion, based on our quantitative analysis conducted on the data from the test sessions we can state that SA is very conducive to integrated planning tasks in container terminal operations. Our qualitative results reflect that the microgame allows for an enjoyable game activity, while providing a meaningful situated learning experience.

Keywords: microgames, situational awareness, planning tasks, transportation

1. Introduction

A lot of working environments today show characteristics of complex socio-technical systems, consisting out of complex physical-technical systems and networks of interdependent actors (De Bruijn & Herder, 2009). For example, a container terminal can be defined as a complex socio-technical system, being an important node in the worldwide transportation network, connecting different modalities of transportation and storing goods (Saanen, 2004). Related to these characteristics, the planning of operations in a container terminal is complex, dynamic and interdependent. Operations that have to be planned are e.g. the location and time of an arriving vessel, the loading and unloading of the vessel, and the further storing or transportation of the goods from the vessel. Current planning practice involves a decomposition of single planning tasks, conducting them in a sequential manner. This approach leads to sub-optimal results, while the container industry is highly competitive, and time, money and quantity of goods handled play an important role (Zeng & Yang, 2009). Such dynamic, complex, and technology dependent work environment requires employees with adaptive skills (Penney, David, & Witt, 2011), characterized by the ability to handle dynamic situations, to deal with stressful events, to manage crisis situations, and to navigate unfamiliar or unpredictable work situations (Pulakos, Arad, & Donovan, 2000). Furthermore, it requires a holistic understanding of what is going on within the container terminal, called situational awareness (SA) (Endsley, 1995).

1.1 Situational awareness

The concept of SA includes the perception of a given situation, its comprehension, and the prediction of its future state (Endsley, 1995), and is seen as critical for successful collaboration (Stanton et al., 2006) and system performance.

The application domains of SA currently range from large-system operations to everyday affairs like driving. SA provides dynamic orientation to the situation, the opportunity to reflect not only on the past, present and future, but also on the potential features of the situation. The dynamic reflection contains 'logical-conceptual, imaginative, conscious and unconscious components which enables individuals to develop mental models of external events' (Bedny & Meister, 1999). However, the most widely used definition for individual situational awareness is 'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future' (Endsley, 1995).

Some of the key benefits of SA for an individual are as follows - SA

- helps generate an up-to-date analysis of the complex and dynamic environment of the individual
- is critical for good decision making under time-pressure
- takes into account the impact of the actions on the surrounding environment
- enhances decision quality
- allows quicker response to abnormalities in the system.

Important features and mechanisms that individuals use to achieve SA include: attention and working memory, mental models, goals and goal-directed processing, preconceptions or expectations and automaticity (Endsley & Jones, 1997). However, SA is not a passive process, as the skills required for achieving and maintaining SA need to be taught and enhanced using specialized training programs. The learning process should also provide feedback to the individual allowing them to understand their mistakes and better asses the situation, leading to the development of more effective strategies and better ways to integrate information (Endsley, 1995). In our research, we have used one such specialized learning approach known as microgames based on situated learning, which are explained in section 1.2.

1.2 Situated learning and microgames

In complex and dynamic systems, where uncertainties will ever remain (Berkes, 2007), it is crucial for actors to gather as much understanding about the system as possible as background for well grounded decisions and actions. Thus, in complex systems, knowledge sharing and learning have become critical competencies for individuals and organizations, leading to increased performance (De Vries & Lukosch, 2009). Nonetheless, the time span between the moment when relevant knowledge is required and when this knowledge becomes obsolete becomes shorter and shorter. Innovative, authentic ways of learning are required to facilitate learning at the workplace, and to update knowledge continuously (Thelen, Herr, Hees, & Jeschke, 2011). Research has shown that there is a huge gap between the knowledge that is needed at the workplace and the knowledge and skills derived from formal learning activities (Tynjalä, 2008). Cross (2007) states that while 80% of the knowledge that is needed in the workplace is obtained through informal learning processes, e.g. by sharing experiences at the coffee machine, using solutions derived from online forums, only 20% if the knowledge stems from formal learning activities, like formal educational courses. This is also stressed by the notion of 'situated learning', an approach that argues for a conceptualization of learning as a social activity within communities of practice (Lave & Wenger, 1991). Informal learning is learning that is predominantly unstructured, experiential, and noninstitutional (Marsick & Volpe, 1999). Organizations nowadays have to encourage learning on the job to enable people to make more informed decisions on what to learn and do (Marsick & Volpe, 1999). As an answer to this particular learning need, it is crucial to develop situated mechanisms that support learning closely to the workplace (De Vries & Lukosch, 2009).

In our work, we explore the use of short games to answer the need for situated learning experiences that are engaging and motivating for an active learner. Unfortunately, not much development and research has been done so far in the field of so-called microgaming. In game design, the term is often used for describing mini-games that are part of a bigger game world. They are often used as incentive or bonus, and then do not always contribute to the overall aim of the main game. In our work, we refer to microgames as a learning experience, representing a stand-alone game with its own aim and meaning.

In a study within a high-school environment (Brom, Preuss, & Klement, 2011) could show that the use of microgames was at least as effective as traditional learning methods. Furthermore, the game group within the experiment was able to retain reinforced and integrated knowledge better than the control group. The microgames here were used as a brief activity between a traditional lecture and a de-briefing phase. Related to our own approach, this experiment focused on high-school students, whereas we try to explore the use of microgames in the professional field and in higher education. Additionally, (Brom et al., 2011) define their microgames as “relatively simple computer games that do not require special skills to play”, which is not applicable to the microgames we propose for the study and understanding of complex systems and situations. (Van Rosmalen, Boyle, Van der Baaren, Kärki, & del Blanco Aguado, 2014) illustrated the design and first experiences with mini-games based on the 4 Components Instructional Design (4C/ID) Method (van Merriënboer /Kirschner, 2012). These mini-games were meant to support students in higher education in acquiring knowledge about research methods. The evaluation showed that it is difficult to find a well-balanced design of the mini-games regarding the information provided – due to their characteristic of being a mini-game, a single game play should not take too much time, on the other hand, enough information has to be transported to play the game and to reach any learning effect. In our development process, we use a game design methodology to find the right balance of information transfer. The terms micro- or mini-game are often used in relation to mobile games, where they refer to the provision of small applications, that can also be used for learning or other serious purposes (Belotti, Berta, De Gloria, Feretti, & Margarone, 2004; Alsmeyer, Good, Howland, McAllister, Romero, & Watten, 2008).

In summary, there is no work done so far on the use of shorter games to foster active, situated learning at the workplace. In this article, we illustrate crucial concepts the microgames are based on, and introduce first experiences we have made with game play sessions. In the following section, we illustrate our concept of microgames. Thereafter, test sessions with students in higher education of the transportation domain and the game design field are illustrated, leading to first results on the experiences with and the usefulness of the microgames. A summary and future steps are presented in the concluding section.

2. The microgaming approach

In order to train skills needed in a container terminal, understood as a dynamic, complex socio-technical system, a microgame called Yard Crane Scheduler (YCS) has been developed. The microgame consists of a simplified representation of the quay side and yard side of a container terminal with the main goal for the player to conduct an interdependent planning of various terminal operations. The microgame approach is based on an instructional concept, called Microtraining (De Vries & Brall, 2008; De Vries & Lukosch, 2009; Overschie, Lukosch, & De Vries, 2010; Overschie, Lukosch, Mulder, & De Vries, 2013). Microtraining represents an approach of short learning activities with a time span of 15-20 minutes for each learning occasion, being based on instructional design considerations like social constructivism, connectivism, and learner typologies (see in more detail De Vries & Lukosch, 2009). Following the Microtraining approach, microgames support situated learning, as they always start from a well-defined problem, which is translated into a short simulation game. The definition of the problem and the translation into a microgame are part of a structured, iterative design process. This design process is based on the Triadic Game Design Philosophe (TGD) (Harteveld, 2011), and starts with a so-called game-storm session. In this session, the three components of a game design as proposed by (Harteveld, 2011) are defined together with the problem owner and the game designer (see figure 1). The three components are reality, meaning, and play, and according to TGD, they should be well balanced in order to develop an effective simulation game.

Figure 1: Facilitating a gamestorm session

The gamestorm sessions begin with defining the reality component of the game, namely making decisions on what aspects of the reference system, in our case, the container terminal, should be represented in a game. Also decisions are made on the fidelity, or the level of realism, the game should represent. This aspect refers e.g. to the audio-visual representation of the physical system that the game should illustrate. After that, the meaning component of the game is defined. This refers to e.g. the learning goals and the target group of the game. The meaning component describes for instance that the learning goal for the microgame introduced here is developing shared situational awareness in integrated planning tasks, targeting at planners working in container terminals. The third component, play, is the last one to be defined, and refers to all game mechanics that should be included in the game. It is for example important, and related to the meaning aspect, whether the game should include competition, and how challenging and difficult it may be for the user group envisioned. When all components are defined, game designers translate the results of the game storm session in a conceptual design of a game, which is again discussed with the target group. When an agreement on the conceptual model is reached, a first prototype of the game is developed, which is then evaluated by experts from the field, in our case, from container terminals (see for more details on the development process (Kurapati, Groen, Lukosch, & Verbraeck, 2014)).

Following the above described development process, the Yard Crane Scheduler (YCS) microgame has been developed. The game focuses on the integrated planning of loading and unloading sea vessels in the container terminal. The game offers two different screens, the operational mode, where an overview of the container terminal is provided, including the vessels to be arriving, the quay cranes, the yard cranes, and the scoring. This part of the screen allows allocating the cranes to the vessels and the containers in the terminal with easy drag and drop operations.

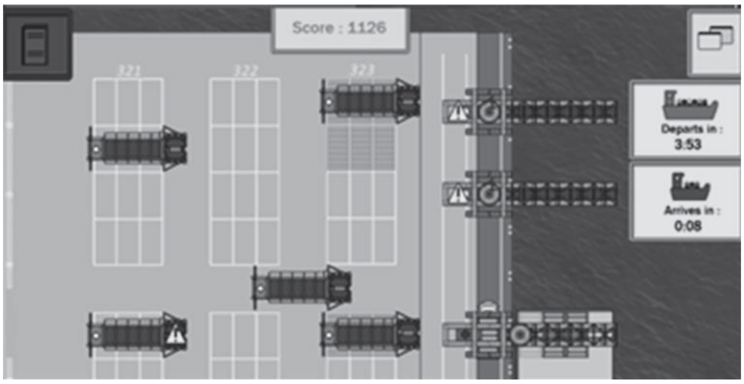

Figure 2: The operational mode of the YCS game

In this mode, game time runs, which has an immediate impact on the scoring of the player. In a negative way, when too many cranes are idle, the time of the idle equipment reduces the score of the player. In a positive way, when a vessel can leave the terminal early, the score of the player increases. In the other, the planning mode, the time freezes, so the player has enough time for planning operations. The main task here is to plan where the containers in the yard and on the vessels have to be placed in order to handle the vessel as quickly as possible.

Figure 3: An impression of YCS game play during a test session

The game's goal is to support the situational awareness (SA) of operational planners in container terminals. In the following, we will report on the outcomes of a case study conducted with game design students to evaluate the playability and the usefulness to develop SA of the YCS game.

3. Case study

3.1 Participants

Between October and December 2014, the YCS Microgame has been played with 142 students in higher education in The Netherlands, Germany, and the United States in total. The population consisted out of students from the logistics field as well as game design students. 38 students formed the game design group. The first two tests with the game were conducted with this group in order to explore especially the playability of the game. Further tests are currently still being conducted with logistics students and with professionals from the field. The game design students were recruited from two classes, one from The Netherlands, from a technical university (N=20), and one from a university of media design in Germany (N=18). The rest of the students (N=104) belonged to the logistics and supply chain domain in Netherlands and the United States. Though the overall sample size is 142, we were able to use only 107 data points, due to incomplete surveys. All the concerned university ethics committees approved our test sessions. We followed their strict guidelines for our sessions, so we could not make answers in the surveys mandatory. In this paper we will discuss the results on the playability of the game and its usefulness to develop SA in general for all students, and will derive more qualitative insights from the game design students with respect to game mechanisms, effectiveness as a learning tool and further improvements.

3.2 Experimental set-up and materials

Within a structured experimental session, the students were asked about their prior experience with games, were given a brief introduction to planning operations in container terminals, and then played the game several times. The researchers took observer notes during game play. Before a de-briefing on the experiences and lessons learned closed the session, the participants were asked to fill in a questionnaire. This questionnaire consisted of 5-point Likert-scale questions, including a self-rating technique on SA known as the Situation Awareness Rating Technique (SART) (Taylor, 1990). The results derived from the post-test questionnaire were calculated using Microsoft© Excel. With this set-up, we were able to combine a quantitative data collecting with qualitative approaches, in order to gather deep insights in playability and usefulness of the game. The experiments were conducted in a classroom setting at the two universities, where laptops were provided to the students for gameplay. An ethical committee approved the experiments and the participation of the students beforehand.

3.3 Quantitative results

The SART measurement of SA consists of three aspects: 1. Understanding of the situation (U) 2. Demand of the situation (D), and 3. Supply of information (S). The overall SA is calculate using the formula

$$\text{Situation Awareness, SA} = U-(D-S)$$

We analyzed the correlations between the performance in integrated planning tasks represented by the YCS microgame score and the SA measure. We found a significant positive correlation between them (Pearson's $r = 0.321$, $p<0.01$, $N=107$). This indicates that students that achieved better performance in the YCS game had higher Situation Awareness. Further, we would also like to report the group averages of individual components of the SA score. The results from the SA related questions imply that the game is able to support the understanding of the situation (m=4.7), while demand of the situation (m=4.7), and supply of information in the game are also high (m=4.4).

In addition to the SART survey, student perception on the usefulness of the game as a learning instrument for integrated planning tasks was measured in the form of a post game survey, by providing the average ratings on a scale of 1 to 5. Results show that the majority of the students state that the YCS game is able to reflect on the need for coordination of various processes in container terminal operations (m=4.1), which is an important requirement for integrated planning operations. The game was also positively valued as providing better insights in the importance of integrated planning (m=3.9). The question whether the environment was familiar to the students, resulted in a low score (m=2.6). This is due to the fact that all the participants were students with limited working knowledge of the professional working environment of container terminals. Despite the unfamiliarity of the environment, the participants were still very well able to gather information from the environment (m=4.7). The players assessed the game as valuable training tool to enhance performance in integrated planning tasks (m=4.0), while the value of adoption of the game by container terminals to strategize integrated planning approaches was given a slightly weaker score (m=3.6), but was still positively evaluated.

3.4 Qualitative results from the observations during game-play

Comments on the game, and suggestions for improvement were observed and written down by the researchers accompanying the test sessions. Students were highly engaged during the YCS gameplay. The facilitator walked around to answer any questions regarding the gameplay by the students. In the first session students had problems logging in the online game portal due to long urls. This issue was immediately rectified by providing short urls for the subsequent sessions. Very rarely, game froze due to technical errors and internet connection lapse, but students were instructed to restart the game when this happened. Students took 2 to 3 gameplay sessions after playing the tutorials to get fully familiarized with the game mechanics. Students enjoyed the music of the YCS game, while only one student reported that it was counter-productive for their performance. Students repeatedly questioned one aspect of the scoring mechanism, where idle resources lose points, for every second they are idle. The motive behind introducing the negative points for idle resources is supported by the industry experts from the container terminal domain. However students found it counter-intuitive and unfair. This concern was raised in all the sessions in both continents. Therefore we are considering modifying this scoring mechanism in the future version of the game. Most of the students wanted to continue playing the YCS game, as we observed from our online portal that several students were actively engaged in the gameplay for several days and some even several weeks after the test session.

3.5 Qualitative results from the observations during the de-briefing

The de-briefing of the game session consisted of a gathering the perceptions of students on the usefulness of the game, playability, player strategies, and possible improvements. This was followed by a lecture by the facilitator linking the objective of the game to practical applications and real world problems.

Many students found that the game very helpful to learn about integrated planning tasks in container terminals. A few students found the game too complex to learn and the actions non-intuitive. Players pointed out the importance of planning ahead. The majority of the players valued the game as well-designed and fun to play. Students suggested several improvements to the game, with respect to scoring mechanism as well as elements to be added to the game to further increase the element of ‘reality’ in the game. The suggestions will be considered for the future versions of the game.

3.6 Summary of results

In summary, the results briefly illustrated here indicate that the YCS microgame is able to address crucial skills needed in complex interdependent planning tasks. A crucial link between the YCS game score and Situational Awareness measure was found which backs the potential of microgames as training instruments for enhancing SA. The level of engagement of students expressed by the students during the game play as well as the debriefing session indicated that the microgame is not only a learning tool, but a highly engaging fun activity, which could further promote interest in learning beyond the game session. Even for students who are not familiar with container terminal operations, the game was able to provide enough information to develop a situational awareness for the need of integrated planning approaches. The comments of the students during game play underpinned that the understood the importance of integrated planning. Nonetheless, also weaknesses of the game were mentioned, and improvements were suggested, which will be implemented in the future version of the game.

4. Discussion and conclusions

Research shows the importance of situational awareness for the performance of complex systems, like container terminals. Specialized training approaches are needed to acquire, maintain and enhance SA in such systems. Designing realistic training processes that are situated in the workplace for such complex and dynamic is very crucial but very challenging. In our work, we try to reduce this research gap by exploring a novel approach known as microgame to enhance SA. We conducted 10 test sessions in Netherlands, Germany and the United States with 142 students to measure the effect of the microgame on SA and also to test its playability and usefulness. Given the significant correlation (Pearson's $r = 0.321$, $p<0.01$, $N=107$) between the microgame score as well as the observations from the gameplay and the reactions from the de-briefing session, we can conclude that microgames have a good potential to be training tools for situated learning to enhance Situational Awareness in complex systems such as container terminals. Students also opined both in surveys and during the debriefing that the microgame was a very useful to understand complex integrated planning tasks in container terminal domain in a short span of time. They also found it to be very fun and engaging. The de-briefing provides an opportunity to reflect on their decisions in the game and think about ways to improve them, which is crucial to acquire and maintain SA. This also strengthens our claim that microgame can be used for situated learning in complex environments to enhance SA. Nonetheless, remarks were made about the complexity of the actions within the game as well as minor deficiencies in the scoring mechanism. In the future, we will explore how the YCS game should be improved in order to increase playability, while still being able to represent the integrity of the planning tasks. The improved version will also be tested with user groups from the transportation and logistics domain, with experience and knowledge about operations in container terminals. We will especially investigate how realistic microgames should be in order to provide a meaningful, but still enjoyable learning experience. This will lead to recommendations for design choices to be made when developing micro- or minigames, used for the support of situated learning and situational awareness in complex systems.

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Integration of Game Based Learning Into a TEL Platform: Application to MOOCs

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Abstract: Some pedagogical activities proposed in the frame of TEL (Technology Enhanced Learning) are not motivating enough, even if the proposed activities are pedagogically effective. Indeed, the principle of following very linear learning paths with little flexibility is not motivating enough for the learner. The current example of MOOCs is quite significant of these phenomena according to the high dropout by learners. In this work, we propose a dual approach that characterizes both the playful and adaptive aspects for MOOCs. The gamification consists of introducing playful activities. Adaptation allows to define personalized learning paths for a student, according to his/her profile, representing the current skills, the preferences, the habits of this student. In our work, we are thus interested in playful and adaptive paths based on the skills of a learner/player in the game-based learning environment all along a learning session. We illustrate the feasibility of our approach with a case study on the "Claroline Connect" platform.

Keywords: game-based learning, MOOCs, adaptation, motivation, learner's profile

1. Introduction

The MOOCs constitute an important development of e-Learning environments because they change practices and uses for distance learning (Daniel, 2012). In recent years, the most prestigious universities in the world have experimented such an approach (Hua, 2013). However, putting this approach into practice revealed many drawbacks (Hollands et al, 2014). Thus, in this context, feedback reports that the dropout is high, only 10% of users enrolled in MOOCs platforms finishing their training (Brown,2013). The reasons for this significant dropout rates are multiple: weak motivation with too classical pedagogical activities offered along a learning session; large heterogeneity of learners. Indeed, each learner necessarily has different levels of knowledge, diverse ways to learn and various expectations. The lack of adaptation of the path causes frustration, resulting in little access to the content offered in the MOOCs. To reduce this dropout, we must maintain motivation. We therefore want to check whether the introduction of a Game-Based Learning (GBL) can improve the attractiveness of MOOCs. In this work, we propose a dual approach; Adaptation and gamification that can offer both playful and adapted learning paths. The first section presents the background and related work around the concept of motivation and attractiveness in a TEL environment. The second section presents our contribution and the different models of the components. Finally, the third section is devoted to an application of the approach in the context of a MOOC platform.

2. Background of motivation in TEL

Motivation is the key factor that encourages learners to carry on when performing pedagogical activities in order to achieve a learning goal. In this context, it can be defined as the tensor of the forces that influence a learner on behavioral or cognitive plan (Pintrich et al, 1996). In a TEL environment, finding the right balance between learning and motivation is a key success factor. Several items enable learners' motivation all along a learning path. In this context, gamification is becoming the most popular concept used to motivate learners (Galarneau et al, 2007).

2.1 GBL and motivation

Nowadays, GBL offers a wide variety of uses and categories (Squire,2003). The term "serious game" can be defined in many ways, in this context (Natkin,2004) propose a wide definition : « […] The use of principles and technologies of video games for applications which have no strictly playful character [...] ». According to (Deen et al,2011), serious games contain « Pedagogical objective, whose property is to arouse the desire to learn». The latter definition offers a basis for reflection on the relationships that can be established between motivation as a key factor in learning and serious gaming. To insure the factor of motivation in GBL, Malone's model (Malone et al,1981) provides us with the necessary conditions to ensure that a serious game is intrinsically motivating. The first condition is related to "a challenge against yourself", where a playful environment enables self-generating objectives to achieve. The second condition concerns the curiosity of the learner/player regarding incomplete paradoxes. The latter condition is linked to the fancy side in a serious game where the environment should make the user emotionally involved. In the same context, the model proposed by (Marty et al, 2011) focuses on both Flexibility and Immersion aspects. They stress the importance of ensuring consistency between the GBL environment and the educational content to maintain motivation in a learning activity. Although the idea of having a learning environment that guarantees the motivation through playful aspects is central, it is insufficient to overcome the lack of attractiveness in MOOCs, where the massive and heterogeneous aspects are also to consider. Adaptation of educational contents according to the needs and expectations of learners is thus a complementary approach.

2.2 The personalization in TEL

In this section, we present some approaches realized in TEL which aim to overcome the problems of attractiveness concerning a learning environment. In this context, some researchers rely on the notion of personalization of paths as a solution to reduce dropout. In this domain, we found personalized approaches centered on the teacher, others on the learner and more recently skill-based approaches. Concerning teacher-centered ones (Franzoni et al, 2009), it is the teacher him/herself who has knowledge about the learners and who proposes the most appropriate pedagogical path for them. Among the approaches focused on learners, those based on the concept of stereotype (Christian et al, 2005) consist in associating a learner with a set of characteristics. The main idea is to ”categorize” every learner by assigning him/her a stereotype describing him/her as precisely as possible. This approach contains a certain degree of approximation, since it is very likely that certain characteristics do not correspond to the associated learner. To overcome this limitation, the notion of learner's profile (Antonija, 1998), is considered as a fundamental component for any personalized learning. The learner profile defines the structure in which all information regarding a student will be stored. This information individually reflects precisely the skills and characteristics of a learner. The proposed personalization is therefore more efficient. In this context, several standards on learners' models [Pain et al, 1996)(Self, 1988), (Kobsa, 2001) present an identity for each learner.

In the previous section, we have presented the richness of GBL as an incentive for learning. We also showed the importance of adaptive aspects on educational contents as a possible solution to increase attractiveness. The question that arises at this level is how to integrate GBL in the TEL environment and more specifically in the context of MOOCs??

3. Towards a playful and adaptive approach in MOOCs

As we mentioned previously, our approach consists in improving motivation and attractiveness in an e-learning environment by a playful and adaptive approach. The following figure illustrates this method.

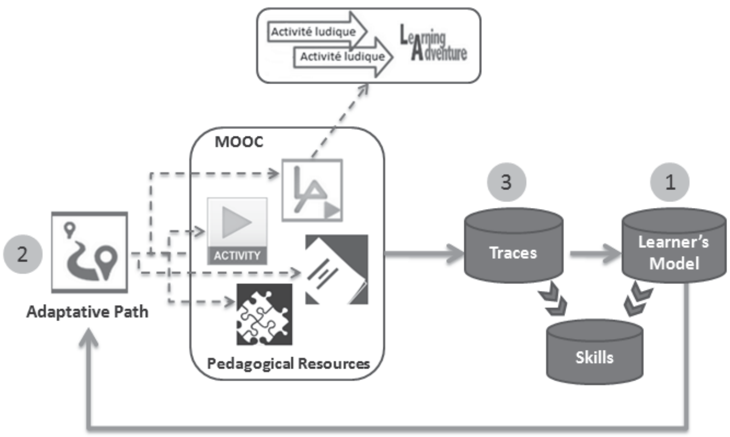

Figure 1: Principle of the approach

Our approach is centered on a learner's model and follows the following process (1). The learner's model (Kobsa, 2001) is a component that characterizes the learner over time. This model mainly contains information about the learner's skills, practices and preferences. (2) Based on information from the learner's model, the system proposes adapted learning paths. The adaptations are possible either on the type of activity (playful activities, collaborative playful activities ...) or on the sequence of activities. For this, we rely (3) on the traces generated during the implementation of activities. The calculation of indicators from traces, allows to update learners' model (Pernelle et al,2013).

In a MOOC context , GBL is integrated in adapted paths and is perceived as a tool to improve the attractiveness and motivation (See following figure).

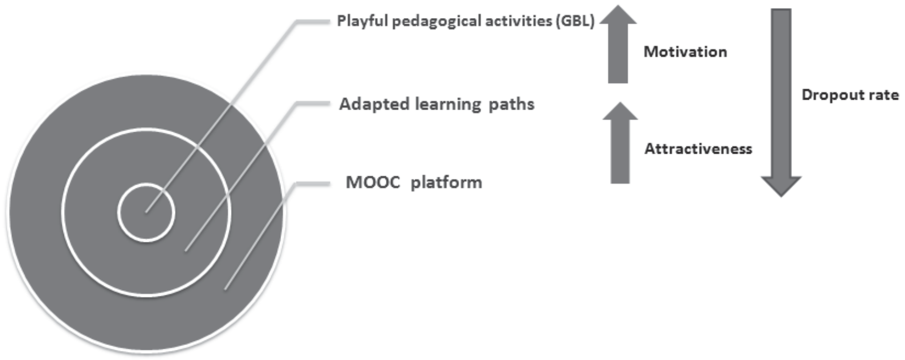

Figure 2: Modeling a MOOC environment

3.1 Integration of GBL in MOOCs

We had to face the problem of introducing some GBL entities in a TEL platform. Additional constraints were to have an immersive world and to allow collaborative learning. We decided to integrate components from a 3D, multi-player environment. Learning Adventure (Carron et al, 2013) is a generic platform for GBL, meeting these constraints. The main idea to achieve this integration is to provide a coupling between the two environments: MOOCs & Learning Adventure. The characteristics concerning the enactment of a pedagogical session on these two platforms are different (Rhythm, duration, assessment of knowledge). We therefore need to establish links between these systems at a good level of granularity.

Most MOOC platforms offer pedagogical resources generally organized in the form of activities and paths. Pedagogical resource is a generic term that means a QCM, a video, an exercise. In the Learning Adventure (LA) platform, the playful scenario consists of a quest which decomposes into actions to achieve in the game (go fetch an object, discuss with a PNJ, etc). Moreover, the LA platform provides access to pedagogical resources in an external environment (document, video,etc).In this context, we have chosen to define a direct association between the pedagogical resources already created in a context of MOOCs with those that will be used by the player / learner along a scenario of the game. For this, the integration process is carried out by an additional component within the MOOC which allows:

- Teachers/ Pedagogical designer define a playful activity within a path and configure these activities to be executed on a gaming environment.
- Learners:
- *To execute this playful activity.*
- *To access simultaneously since the game or the MOOC to associated pedagogical resources.*

This generic component appointed "Game Resource" is modeled in the section (**3.2.2**)

After describing the integration approach of playful aspects in MOOCs, the goal is now to model the approach presented in this section.

3.2 Modelling approach

In this section, we present the structure of various necessary concepts to set up the playful and adaptive aspects of our approach proposed in a MOOC platform.

3.2.1 Learner's model

As we mentioned in the last section, our approach is centered on a learner's model. In our work, we have proposed an extension of user model (Kobsa,2001). This model is built both by implication and the other explicit. The implicit aspects are generated from the learner's traces obtained from actions made by the learner either while performing activities in the GBL platform or in the MOOC platform. The learner enters the explicit aspects according to his/her preferences..

In the context of the implicit aspects, a trace characterizes an action that a player can perform in the Learning Adventure game (get objects ...) or in the MOOC (watch a video, do a test ...). Each trace is generally characterized by:

- IdTrace: The identifier of the trace.
- Server: The server that is running the game.
- Time: The date in which the trace is performed.
- Login: The player who made the trace.
- Type: The type of trace.

These traces constitutes the primary inputs which will allow calculation of indicators to enhance the learner's model (Figure 3)

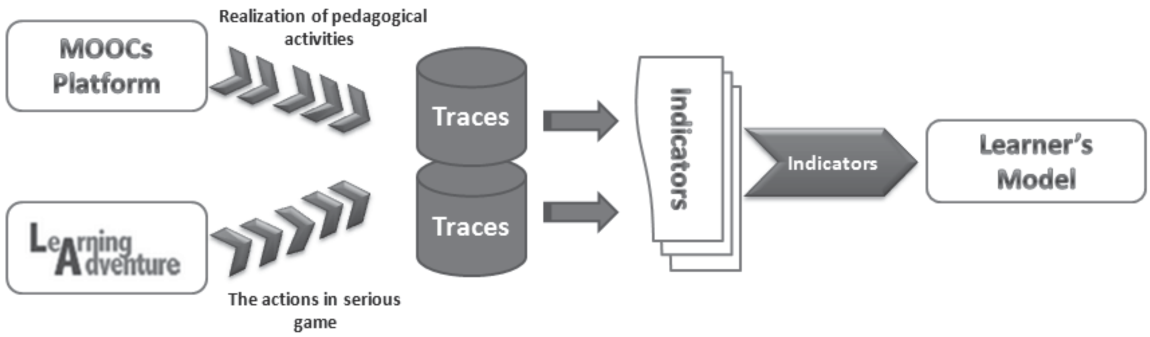

Figure 3: Approach of learner's model conception

We present in the following diagram (Figure 4) the various elements which will be stored in a learner-centered numerical model (LCNM). Most of the information concerns the learner's profile, characterized through criteria established by teachers, the learner's preferences on learning methods(more playful activities, duration of a training session less than 30 m, etc.) and skills acquired over time.

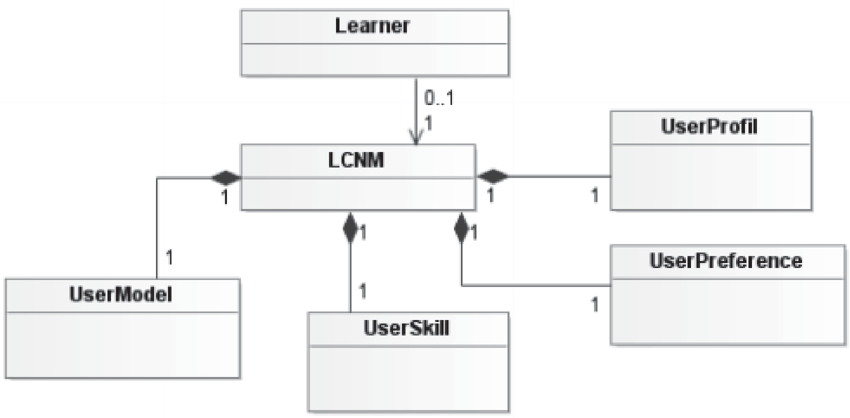

Figure 4: Class diagram of the components of learner's model

After describing our learning model, we present the different concepts concerning the characterization of the playfulness in a MOOC environment.

3.2.2 Generic playful elements

In this section, we detail the structure of different modules used to allow the integration of playful pedagogical activities within MOOCs. In this context, teachers specifically use some concepts while others are available for learners. Concerning the teacher we propose:

- The resource «Game Resource»: allows the teacher to create a playful pedagogical resource in a MOOC platform, namely «Claroline Connect».
- The game configuration concept: it is used to enable the configuration of a scenario using GBL. In the case of a multi-player environment, the configuration must also specify the identification elements in the MMO server (in our case, the Learning Adventure server). We present in the following table the different information that characterize a configuration of a serious game.

Table 1: The elements of a configuration of a serious game in the MOOCs

The elements of the configuration of a serious game	Role of the element
Configuration Name	Configuration Title
Url of main program	Url of the server where executable of serious game is stored.
Url of the traces	Url of the server where the traces of a player in a serious game are stored.
Url of the user's model	Url of the server where the skills, preferences and objects of a player in a serious game are stored.
VersionLA	Specify the version of the serious game
ScenarioLA	Determines the scenario to achieve along a serious game

- The indicators are constructed from user's actions (and traces) with the GBL environment .They are used to analyze the player's behavior. Behavioral traces from the playful activity in the serious games can thus supplemented with traces of activities within the MOOC.

About learners, they have the opportunity to exploit these playful elements:

- The playful activity: it allows learners to launch a serious game scenario from a learning path of the MOOC. It enables an effective integration of serious game in the process of learning.
- The «bagGame» is a container of all the interesting objects found by the player in the serious game. Some of these objects will support pedagogical goals and correspond to a MOOC resource. Other objects will be meaningless except in the context of the Game.
- The «traceGame» are all traces produced by the player in the GBL scenario. It seems to us essential that each player/learner can access all traces that s/he produces. However, these traces can't be changed.

Figure 5 presents the class diagram of the main concepts necessary for the integration of play activities in MOOCs.

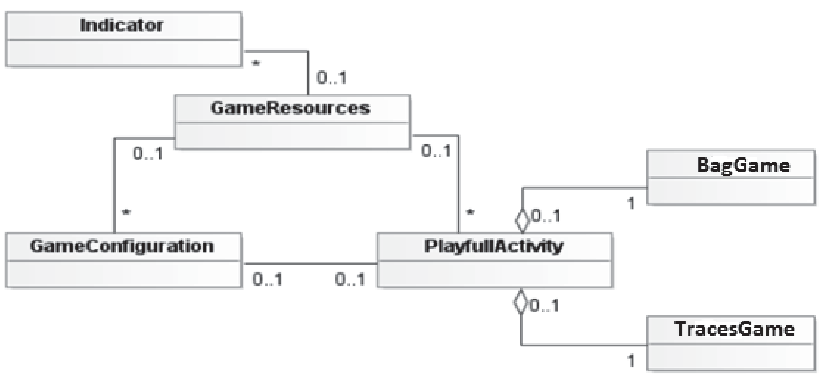

Figure 5: Class diagram playful elements

3.2.3 Adaptability mechanisms for learning paths generation

We turn now to the adaptive aspects allowing to generate more flexible learning paths. In a serious game (SG), the adaptability of the playful scenario is generally partially supported. This is especially the case for MMORPG (approach based on multiplayer role playing). This is generally implemented by defining additional quests. For instance, in Learning Adventure, the user model identifies each learner according to their pedagogical needs within the game. In the context of integration SG/MOOCs, we propose to make the adaptation possible in learning paths, by relying on learners' skills.

In this section, we present our strategy for personalizing learning paths. In this context, we thought to enrich the learning environment by a semantic dimension used to structure and configure a repository of skills in MOOCs. In this context, every pedagogical activity in a path will be configured by the acquired and required skills that set the condition under which this activity is accessible for the learner. In this context, we have added a semantic layer for structuring a learning path by a sequence of skills.

With this approach, the proposed learning path will be adapted to the learner's skills at any given time. We model the concepts needed to generate the paths by the class diagram below (Figure 6).

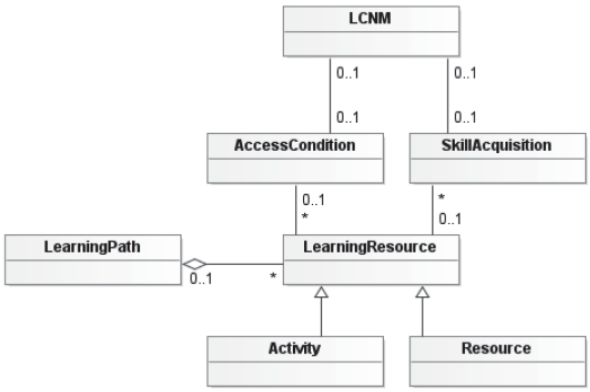

Figure 6: Class diagram of Learning Path

In order to validate our proposals, we have chosen to implement the main concepts proposed in a new MOOC platform: «Claroline Connect».

4. Application: Learning adventure and Claroline Connect

To justify the importance of our proposals, we choose to implement models on a new platform MOOC: Claroline Connect .Interaction between Claroline Connect and the Learning Adventure platform will occur. In this section we start by introducing the platforms Claroline Connect and Learning Adventure and an example of a scenario which emphasises the playful and adaptive principles in a pedagogical training session.

4.1 Claroline connect

The Claroline Connect platform can be seen as a platform for a dual approach (cMOOC or xMOOC). It is based on a flexible structure of shared spaces and the ability to integrate rich content (documents, videos, quiz, ...). Claroline Connect is developed with the Symfony2 framework. First MOOC experiments on this platform have began. Among the available MOOC, we can cite the MOOC Elearn2 (Elearn2, 2014) and the MOOC Fofle (Fofle, 2014). For our work, previously identified concepts were implemented as components (Bundle) in Claroline Connect.

4.2 Learning adventure

Learning Adventure is a generic Serious Game environment based on a role-play approach (Baptista et al, 2008)(Yu, 2009). The players (students or teachers), possibly represented by their own avatars, can move through the environment, performing a sequence of sub activities in order to acquire knowledge. This environment is generic in the sense that the teacher can adapt the environment before the session by setting pre-requisites between sub activities and by providing different resources (documents, videos, quizzes) linked to the course.

4.3 Example of playful and adaptive integration

To validate our proposal, we rely on a MOOC module in the field of engineering sciences. This module proposes to explore the industrial information systems known as PLM. For this, we have integrated a playful scenario developed for PLM (Pernelle et al,2012) as a specific MOOC activity.

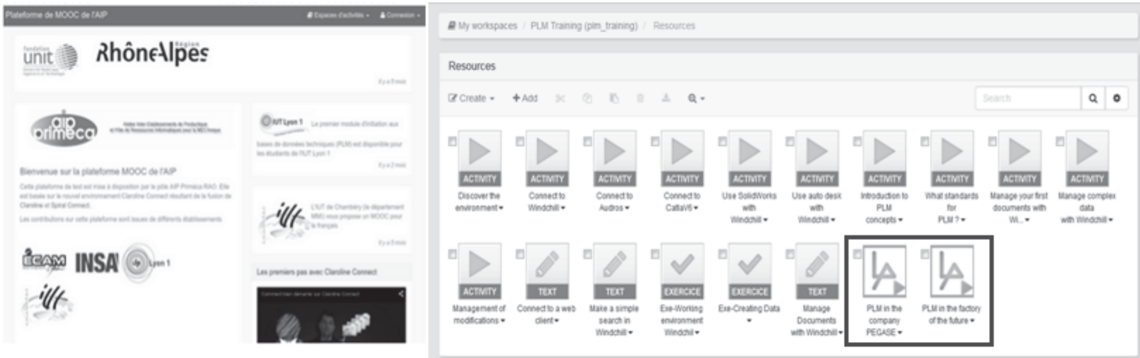

Figure 7: PLM MOOC elements

The previous figure (Figure 7) shows a part of pedagogical resources in the PLM MOOC. In these resources, two playful activities correspond to a scenario of serious game on the PLM. For the player, the realization of these activities triggers the creation two objects in his/her personal space:

- The container of all objects recovered during his/her quest (Bag).
- His/her traces of activities enable to visualize his/her progress in the GBL environment.

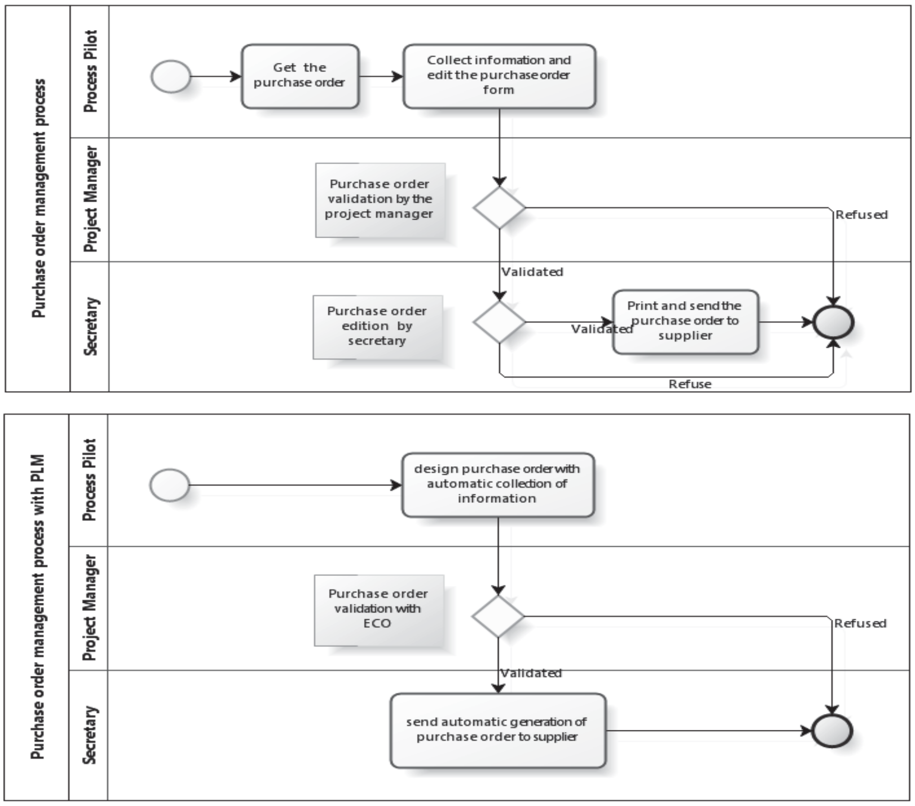

Figure 8: Purchase order management process with and without PLM

For the first scenario of serious game on the PLM, we have modeled a company building from the actual architectural plans in order to ensure the players' immersion (Figure 9). This activity in the MOOC are raising people's awareness of PLM. So, we have chosen a simple industrial process (purchase order) described in figure 8. Without a PLM system, this process is achieved through traditional activities in which the risk of error, as well as the tedious tasks involved, should be considered. Once the process has been carried out without a PLM system, the mistakes made by the user are displayed. A short training session on possible solutions to solve their mistakes with the Audros PLM system is then proposed.

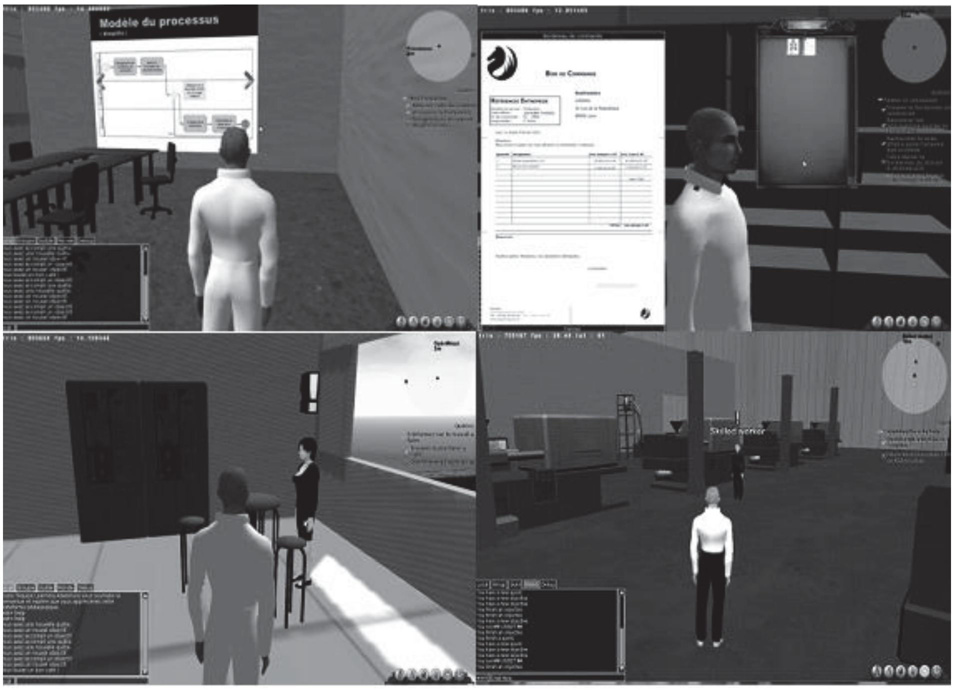

Figure 9: The Learning Adventure serious game environment for PLM

When the scenario is finished, learners can access learning resources found in the game and see their traces (Figure 10)

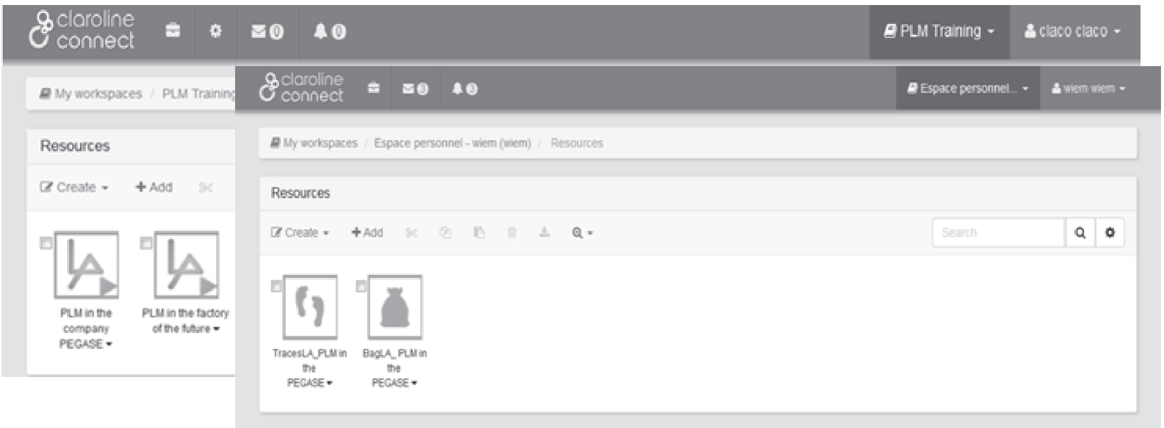

Figure 10: Playful elements in MOOC PLM

The following figure shows the capacities of path adaptation. Figure 11 thus describes the skills identified for this module by specifying for each skill the score needed to reach a level of difficulty along the training. Figure 12 shows an example of path displayed in the learner's personal space. The activities are optional depending on the skills.

The training of PLM began to take place with students to validate their proposals. However, we prefer to consider this phase as a test phase.

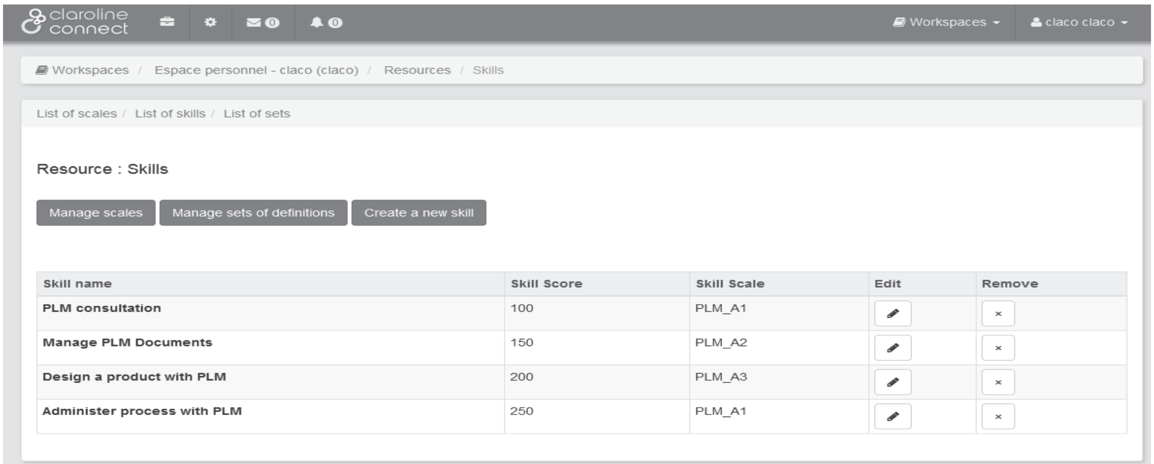

Figure 11: The skills in PLM module

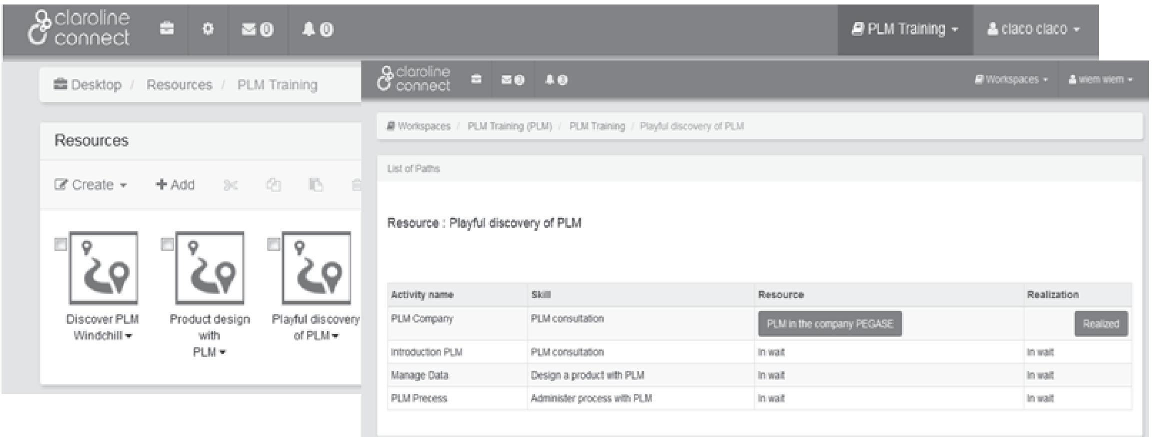

Figure 12: Pedagogical path for the formation of PLM

5. Conclusion

In this article, we proposed an approach to improve the rate of dropout in MOOCs. This approach is based on a certain vision of the learning path so that they are more flexible and playful. We propose a generic structure to integrate activities within a GBL environment and allow a certain adaptability of paths (difficulty level, choice and sequencing of modules). The proposed models were implemented in a MOOC platform Claroline Connect and a use case on industrial information systems is under development.

For future work, we would like to introduce other immersive features, concerning alternate reality, introducing several activities in mobility via tablets, smart phones or tabletops for collaborative activities. In our view, a significant amount of work remains to be done on the visualization of learners' profiles to summarize the principles exposed in (Carron et al, 2009). We must also improve non-player characters’ behaviors in order to make them more credible, allowing them to make decisions (through multi-agents systems (Carron et al, 2001), to provide us with tracking help facilities or to motivate punctually the learners.

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Cities at Play: Children's Redesign of Deprived Neighbourhoods in *Minecraft*

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Abstract: This paper presents a community-driven science gaming project where students in collaboration with urban planners and youth project workers in the City of Copenhagen used *Minecreaft* to redesign their neighbourhood to generate solutions to problems in their local area. The project involved 25 children from a school located in an exposed area in southern Copenhagen ages 13–15. The redesign process was conducted as part of science education in eighth grade. The specific area in southern Copenhagen has problems with organized crime and gangs and is defined as a focus area for various projects administrated by the City of Copenhagen. Resources were allocated for one of these projects to recondition the subsidized housing for this area. A community-driven science gaming process was designed in which overall challenges for redesign, defined by urban planners, were given to the students to highlight their local knowledge about living conditions and solutions for the problems identified. As part of the process students were introduced to central concepts in urban planning defined by leading Danish architects. Over four days, the students defined problems and potentials of the area, constructing models for redesigning the neighbourhood in *Minecraft* and LEGO. These were presented to City of Copenhagen architects and urban planners as well as the head of the Department of Transport, Technology and Environment. Overall the study showed that tasks focused on solving local living problems through neighbourhood redesign were strongly motivational for students. During the process students constructed models focused on the various needs of different types of residents and argued the models' redesign, in terms of their local knowledge area and in terms of fulfilling the mixture of needs of different groups of residents. This paper presents the *Cities at Play* research concept and explores the potentials and pitfalls of introducing user involvement in community-driven science gaming environments for integrating exposed groups.

Keywords: community-driven science games, urban planning, science education, citizen science

1. Introduction: Community-Driven science and games

Involving citizens or laypeople in production of science outside the walls of formal research institutions is traditionally defined as citizen science. Opportunities to involve citizens have increased with web 2.0 technologies and other types of digital platforms. New digital platforms are changing how laypeople are involved in technical and scientific processes and production that affect their lives (Delfanti, 2010). The development of scientific discovery games within the past couple of years introduces new elements into the issue of game-based participation in a science classroom setting. The main goal of this category of games is to create a platform that enables and motivates players to contribute in solving scientific problems (Cooper et al., 2011). The most well recognised example of this class of games is *Foldit*, which is an online puzzle game where players participate in folding amino acid chains to form new protein structures. Presented with a primary protein sequence or partially folded structure, players need to find the – often-unknown – lowest-energy three-dimensional structure. Players manipulate the protein structure by pulling, twisting and tugging the protein backbone and side chains into various configurations (Good & Su, 2011).

One trend in development and studies of science game formats in the past decade is exploring the ways in which game media can facilitate new approaches to authentic science education. Examples of this are games in which players become urban planners, biologists or forensic experts drawing on the authentic tools, processes and values of specific professions (Shaffer, 2006; Squire & Klopfer, 2007; Magnussen, 2007). Where the major trends have been to *simulate* authentic technical or scientific processes in game environments for the purpose of students learning *about* authentic science, *scientific discovery* games or *citizen science* games now focus on gamifying professional research or technical processes, allowing and motivating players to take part in generating results for authentic application in scientific research (Cooper, 2015; Magnussen et al., 2014). Interesting issues arise, however, in relation to this class of games that need to be addressed when discussing the integration of creation of new knowledge and authentic science practice in science education. Even though the games integrate professional values and tools, they remain simulations of professional practices. This aspect of the games brings up the matter of whether students learn to work as a scientific expert or whether they learn how to be a scientific expert. This may depend on various design elements of profession simulation games. First, the clients and experts students collaborate with in the games are fictional characters with fictional problems that need to be solved to play the game in school but that do not have relevance in the world outside school. Second, the fictional problems to be solved in these games often follow a linear path and have a clear starting and end point. This is clearly different from real-life professional problem solving, where the processes are more multidimensional. Finally, even though these types of games have been shown to support student creation of new process tools (Magnussen, 2007), the solutions are often pre-defined and already known by the teachers. This stands in contrast to the real-life open-ended tasks professionals face and that can be carried out in various ways, the chance of success or failure always an issue to be considered.

Scientific discovery games address these issues that exist outside a formal learning setting. The main goal of this type of game is to create a platform that motivates players to contribute to solving scientific problems.

The goal of the research presented in this article is to expand the scientific discovery game concept in an educational context. In the presented project students gained first-hand experience creating new technical knowledge within the framework of professional architects. This community-driven science game environment aimed to create the experience that this knowledge is not static, but constantly evolving. However, there are educational challenges in designing this type of game. Scientific discovery games have the potential to introduce authentic environments, grounded in real-world experience, generating new scientific knowledge in science education. Therefore, it is crucial to understand if and how the game environment contributes to students' experience of participating in research. Understanding the potentials and implications of this type of citizen-driven game environment and the effects of the game and subsequent learning experience on different types students is another focus of the project.

2. Cities at Play

The citizen-driven science game environment *Cities at Play* described in this paper was developed in close collaboration with the Copenhagen City Council Social Services Department and ResearchLab: ICT and Design for Learning at Aalborg University in Copenhagen. The purpose of *Cities at Play* was to involve young people in deprived areas as experts in their own living environments and to educate them on the influence of structural factors on their welfare and wellbeing and in how to use game tools to apply their knowledge and ideas to recreate and strengthen their neighbourhoods. From the start the project was launched to define problems and introduce game-based methodological solutions for developing structural changes in neighbourhoods in deprived areas in Copenhagen, therefore including both social and educational objectives. The project aimed to provide authentic contributions to City Council urban development and planning as a starting point and, ultimately, in realisation of some of the ideas contributed. As illustrated in figure 1 the project will move through three different stages, including an increasing number of schools and a number of departments in the Copenhagen City Council, employing games as a tool for exchanging challenges, ideas and explicit redesigns of structural issues in deprived areas.

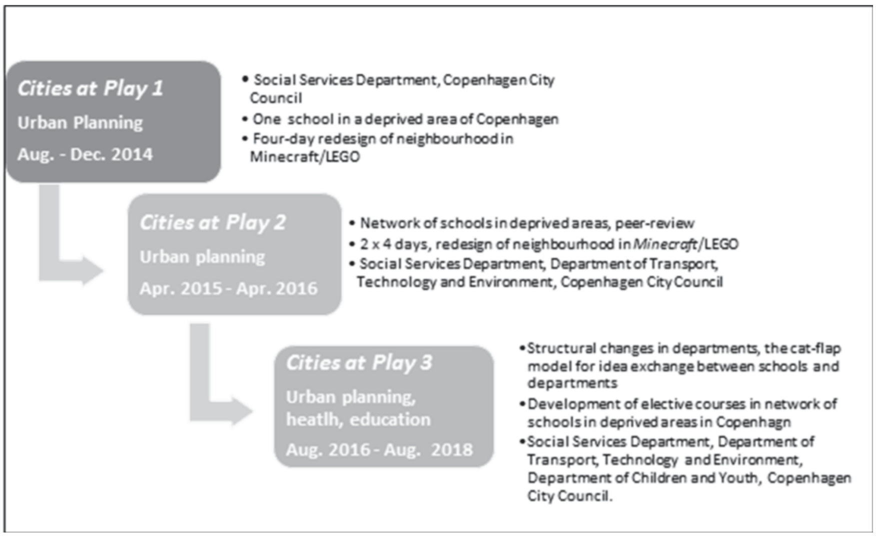

Figure 1: The three stages in *Cities at Play*

The project presented in this paper is the first stage in this 3-stage plan (see figure 1) with focus both on designing play-based, community-driven science learning environments in schools and on introducing structural changes in departments of the Copenhagen City Council as a gateway for integrating citizen community knowledge and generating ideas in central decisions and actions to change conditions for citizens in deprived areas in the city.

2.1 *Cities At Play 1*: The citizen game design and methodologies

In this paper we present how, in autumn 2014, students redesigned their neighbourhood in *Minecraft* and LEGOS based on architectural core concepts in urban planning and the challenges defined by leading architects from the Copenhagen City Council. In 4-day development process the students went through five phases inspired by innovation process models (presented in Table 1).

Table 1: Students development process in *Cities at Play 1*

Phase	Title	Process
Phase 1 (day 0, 1, 2 & 3)	Inspiration	Field trips, introduction to core concepts in urban planning
Phase 2 (day 1)	Problem definition	Definition of core strengths and challenges in their local area
Phase 3 (day 1)	Ideation	Development of ideas for solving local problems and strengthening potentials
Phase 4 (day 2 & 3)	Modelling	Building models in *Minecraft* and LEGO
Phase 5 (day 4)	Presentation	Presentation of models for the head of the Department of Transport, Technology and Environment and urban planners of the Copenhagen City Council.

The methodology used in developing the components of *Cities at Play*, known as the Quantum Computer Game, followed a design-based research process involving various design cycles, interventions, analyses and redesign (Brown, 1992). In the first iteration described in this paper, design-based research was applied as methodological frame and various methods were employed in the development and investigation of the game-based community-driven urban planning environment.

The design phase and the first design were based on previous studies and results of community-driven science environments and on testing and experimenting with new tools, designs and elements (Magnussen, et al., 2014). This was partly previous projects in the Social Services Department and partly studies from new types of community-driven science games (Magnussen et al. 2014), which will be described below. *Cities at Play 1* was designed in a collaborative process between youth street workers, researchers, teachers and urban planners of the Copenhagen City Council. Aiming to create a game-based format to generate authentic contributions for the Copenhagen City Council, it was essential to integrate both sides in the study design phase.

The first intervention in *Cities at Play* included teachers and one 8th grade class with 25 students ages 13 – 15 at a school in an deprived area in Southern Copenhagen. The area was identified as a focus area, as it citizens experience severe problems with gangs and drugs. The school is located in a closed area with older council housing. A library, kindergartens and a nursing home are part of the school the area. The project was conducted in the library over a 4-day period. Video observations documented the 4 days of student design sessions. Pre- and post-surveys gauged the changes in students' knowledge about urban planning and their local area and their understanding of the ability to structurally change their living conditions. Qualitative interviews with teachers and students focused on understanding the possible outcomes and challenges of the project. The first results will be presented in the section below.

2.2 Cities played and first results

The *Cities at Play 1* design employs 5 phases and is based on experiences and results from previous studies of community-driven science games (Magnussen et al., 2014). As part of raising the citizen perceptions of security in their local area, Social Services Department conducted a citizen-driven design project in an area in Southern Copenhagen. IN this project, students redesigned parts of their neighbourhood with specific focus on creating a safer neighbourhood. The project was successfully presented to the City of Copenhagen's head of the Department of Transport, Technology and Environment, who had allocated funding for the implementation of student-designed changes in regard to a path, which was perceived as specifically unsafe by the participating students. This project was a smaller project involving only two students and was not documented by research. The project did however produce successful results that were applied to the Copenhagen City Council's solutions in the local area, thus demonstrating the potentials of including students in local urban planning. It was consequently decided to attempt to scale up the project and include new game-based tools. The game tools were chosen to allow students to easily visualise their ideas and communicate first-hand experience of the constructed areas and suggested changes. In Denmark a complete geographical open-source model of Denmark is offered by Danish Geodata Agency (http://eng.gst.dk/maps-topography/denmark-in-minecraft/), making it possible to download a 10x10 km area with all existing buildings and streets for students to redesign.

Apart from the described pre-project, the *Cities at Play 1* design was based on results from previous community-driven science research projects (Magnussen et al., in preparation). These studies showed clashes between players' perceived lack of expertise for contributing to scientific and technical fields and motivation for playing these games and perception of learning (Magnussen et al., in preparation). It was therefore central to the design to choose a setting in which participants enter the project with clear expertise and first-hand knowledge about living in the local area, along with guidance from knowledgeable architects and urban planners. Education in architectural development and urban planning processes along with scientific and technical competences were central to building student expertise and confidence. The research focus was thus both on understanding what competences students gain in game-assisted research-generating education and furthermore to understand what motivates participants in these types of games and game-based environments.

As described in the previous section the project was defined in a collaborative process between researchers, youth street workers, teachers and architects of the Copenhagen City Council. Youth street workers from the Copenhagen City Council had identified a social housing area in the Southern Copenhagen region with different types of problems related to gang-related crime. The greater area of the southern region of Copenhagen will go through great changes in the coming years and urban planners were highly interested in receiving concrete suggestions from the students on how their the social housing area and neighbourhood could be changed. Improved social life and better connections to other parts of the city are central to the teams' redesign of the Southern Copenhagen area. Two overall questions and tasks were defined to guide students' redesign focus: A. How can you redesign your neighbourhood to create more social activity and social life? B. How can you rebuild the area to create coherence within the neighbourhood and connections to the surrounding city? With these overall questions in focus a five-phase process was designed (IDEO, 2012; Table 1). Observations and results from the different phases will be described below.

2.2.1 Inspiration and problem definition phases

The focus of the initial phases was to inspire students to rethink structural possibilities in their local neighbourhood and to define the problems and potentials of the existing structures. It is well-known that fundamentally rethinking existing formats is challenging even for experienced innovators and designers (IDEO, 2009). Previous studies of student innovation processes demonstrated that the process of thinking about new designs in an everyday context and not rejecting innovative ideas is highly challenging for 13–16 year olds (Magnussen, 2011). It was thus critical to initiate the process of inspiring students by introducing them both to other types of neighbourhoods as well as central principles of architecture and urban planning. This inspiration was repeated with varying content at the beginning of each day. Before the four-day development process was initiated we also arranged a field trip to an area in northern Copenhagen. The northern Copenhagen area has a history of the same type of problems as the southern area regarding gang-related crime. North Copenhagen has however developed into an attractive area with a high level of cultural diversity and a high degree of social street activity with a high density of cafés and outdoor life. Urban planners in the Copenhagen City Council recommended this area to inspire students' motivation because social activities have been strengthened by structural changes such as enabling café owners to serve outdoors by closing streets for traffic. Because of limited resources at the school it was not possible to invite the whole class to take part in the field trip. In collaboration with the teacher it was decided to select one 'super user' from each group. The five super users were selected based on their experience with the game *Minecraft*. This resulted in the selection of five boys who were, as the teacher pointed out, "never chosen for organising tasks in groups; it's usually the girls who are selected as leaders and organisers in group work." The five super users went on the field trip to photograph social street activities and structural changes made possible by these activities. These pictures were used in the inspiration phase at the beginning of day 1. Using the super user's pictures, students received an overall introduction to central architectural concepts in Danish urban planning as well as to how trends in urban space planning have changed aesthetically and functionally over the past five decades. Specific architectural concepts in Danish urban planning were introduced and discussed throughout the four-day development process. These were specifically concepts related to the two overall tasks: strengthening social life and coherence in the area; such as concepts of placemaking with focus on building cities to create spaces for social life and how these spaces should be created by local communities, be visionary, continually be able to change to adapt to use and host several different functions such as play, shopping and work to inspire people to social interaction developed by the Danish architect Jan Gehl (2010).

A central aim in the project was to both focus on participants' expertise and on delivering the types of architectural knowledge students need to be able to apply their local knowledge about the neighbourhood to developing qualified suggestions to professionals on how to structurally change the area. The reason for focus on the student-as-expert was based on results from previous studies that demonstrated the importance for players playing community-driven science games to understand (and be motivated by) the expertise they are able to contribute within the collaborative processes of game environments (Magnussen et al., 2014; Magnussen et al., in preparation). Highlighting students' expertise and first-hand knowledge about their local city space was therefore, as described earlier, a focal point for introducing the overall project. It was however in the problem and development phase that it became clear how central the local knowledge was in the game-based urban design space.

Prior to the four-day development process, students were asked to complete an online survey with questions on their knowledge about the local area and possibilities for redevelopment. Eight students out of 20 filled out the survey. To the question: "What is good about living in Green Garden?" (name of social housing area changed for anonymity), students answered: "the school is close by," "you live close to central Copenhagen," "all the friends," "there are playgrounds for small kids, kindergartens and after-schools facilities and things like that," "it is cosy and close by" and "solidarity, unity." When asked: "What is bad about living in Green Garden?" five out of eight students answered either that there is crime or "a lot of crime" or "troublemakers" or that it feels "unsafe at times." Other answers were: "it lacks activities for older children," "a lot of traffic," "the roads are worn" and "you hear a lot about a lack of unity."

In phase 2 the problem definition phase in the four-day development process (see Table 1), students were asked: "What potentials and challenges are there in Green Garden? Is it the same problems everyone has: adults, children, people who work at the library, people who have business?" and were given the task to list the strengths and challenges in Green Garden. The focus on teaching students to view the problems of the area, potentials for change and alternative designs were defined by the urban planner of the Copenhagen City Council. The urban planner pointed to that citizens invited for involvement workshops often lack the competence to see the changes needed from the perspective of many different types of citizens and focus on minor details, such as "if the swings need paint," lacking competences to view the overall considerations involved in producing ideas for changing the city space. Therefore, one overall learning goal was to teach students to view and discuss what the structural changes in their suggestions and ideas contributed to changing the quality of life for different types of citizens.

Initially, the four-day process was met with scepticism by some of the students. Regarding contributing ideas to the Copenhagen City Council, one student commented that, "They don't listen to us anyway," but this radically changed and the problem definition and design phases proved very intense, with highly engaged and motivated activity from all students. The answers from the physical definition of problems and strengths in phase 2 in the class were less focused on problems related to crime and more focused on structural problems and strengths. The problems listed included: poor lighting (Green Garden is "very dark" at night); inferior housing and worn down apartments; the scattered nature of activities at e.g. the library and youth club; poorly maintained green spaces and playgrounds, and how cut-off or "hidden" Green Garden is from the rest of southern Copenhagen, making it difficult for outside visitors to find and see and for residents to interact socially with other neighbourhoods. A strong community feeling was identified as a specific strength of Green Garden.

2.2.2 Ideation, model construction and presentation

The focus of phase 3, the ideation phase and phase 4, the modelling phase (see Table 1) was for students to develop ideas and game-based models of structural solutions to the problems identified in phase 2. Students were asked to list and draw designs to strengthen identified potentials and solve the identified problems of Green Garden. The questions for this task were: How can you change Green Garden so potentials are strengthened or problems are solved? List as many ideas as possible for new things to replace things that need to be demolished. How do these ideas solve problems for different people? The developed ideas were characterised by either a specific focus on structurally solving identified problems or by being more theoretical with conceptual plans and examples for changing the social life of or coherence in Green Garden. Examples of the first type of ideas were developed by group 2, which worked on the problem of Green Garden's physical separation from other neighbourhoods in the southern Copenhagen area and focused on creating new types of housing to appeal to families, young people and the elderly. With the slogan, "Green Garden for everyone," there were ideas developed for a new type of triangular flat, the aesthetics of which would attract people who were stronger socioeconomically and would have a positive influence on the mix of different types of residents and on the image of Green Garden as a rundown and unattractive area. The functional aspects of the triangular housing were however challenged by the other groups, who questioned the physical feasibility of the triangular design for other residents, as appealing to bachelors. An example of a more conceptual idea was presented by group 5. With the slogan "Bring the City to Green Garden," they argued that focus should not be solely on creating paths and roads to the surrounding city. Their main idea was to create attractions to inspire people from the rest of the city to visit Green Garden. As an example, they suggested tunnels to accommodate the heavy traffic on the big road passing outside, with the aim of using free space for a shopping street closed to traffic. In the modelling phase, they focused on illustrating their "Bring the City to Green Garden" concept by building examples of designs in this shopping area, such as a glass bridge for shoppers. In contrast to this, Group 2 decided on building a complete redesign of Green Garden. Blocks of flats "hiding" the area from the passing road had been demolished along with part of the old housing. New types of family housing with gardens were mixed with apartment buildings, with smaller flats for single people. The redesigned area also contained fitness facilities, a playground and kindergarten, and after-school facilities were placed in the same area. The group argued that their redesign aimed to create an area that different types of people would find attractive and that contained various activities to enhance the possibility of forming communities of common interest, such as physical exercise. The three other groups suggested new types of "experience cycle paths" and bridges to connect Green Garden with the rest of the city. Two groups suggested complete redesigns of an existing playground, with focus on physical activities for younger and older children and built-in community facilities and cafés, where people could meet while their children played at the playground. The school and nursing home were integrated into these models as designated for keeping the garden and restoring the playground.

The identified problems and resulting *Minecraft* and LEGO models were presented to the head of the Department of Transport, Technology and Environment and participating architects who had taken part in defining the overall tasks. The visiting professionals posed questions, commented and challenges to the different models. Overall the architects commented on how the groups had managed to redesign Green Garden with respect to different types of citizen needs:

> *"Often users only see changes from their own perspective – whether they need, for example a new swing (…) It's impressive that you produced competent proposals for structural changes in Green Garden that would benefit everyone and that are parallel to many of the initiatives we think about as architects" (Thomas, architect and urban planner, Copenhagen City Council, transcript of video observations, 18 December 2014).*

In response to the content of the ideas and models, it proved more challenging for professionals to understand the *Minecraft* format of the models. The groups had produced three-dimensional walkthroughs of the developed urban designs. The architects were not experienced with *Minecraft* and explained how it was difficult to follow the demonstrations in the game format. During the development process, and in the interview after the completion of the project, students described how *Minecraft* was an easy tool to use for them. One student noted that, "the tools were easy but the thoughts and problems were difficult." Students also described how *Minecraft* models gave "the feeling of being there," whereas the LEGO models provided good overviews of the whole model. In interviews after completion of the project the majority of students also indicated that one of the most exciting elements of the project was that their ideas were used for "something real." One student described the experience as "confidence-building." And it was notably exceptional that all of the students in the class participated during the whole period.

3. Discussion and conclusions

The project showed that over the course of the four-day development process students changed from defining challenges in their neighbourhood in terms of less structurally-defined problems, such as "crime" and "feeling unsafe," to structurally-defined problems such as poor lightning, worn down housing and streets, and the scattered nature of community activities. These structural, well-defined problems created the framing for the students' development of redesigns for their neighbourhood, leading to designs, suggestions and plans aimed at structural changes to meet different types of citizen's needs and problems. The authentic framing of the models being presented to and commented on by real urban planners proved to be highly motivating for both resourceful and less-resourceful students. Central to the *Cities at Play 1* project was the need for equal focus on both students' understanding of structural frames for developing cities and on developing structures within public bodies to respond to, and potentially take up, ideas generated within communities. This first stage of *Cities at Play* revealed challenges in finding formats to integrate student's ideas into the central work and decision making within the Department of Transport, Technology and Environment. Games as a design tool were perceived to be an easy tool by students, but models designed using *Minecraft* proved to be a challenge for the architects to relate to. Thus there seems to be the potential for focus on the craft of creating game-based models, for understanding the potential of game-based tools and for creating game-based representations of ideas and models in alignment with the professional practice of architects and decision makers.

One focus in the next phase in the overall *Cities at Play* project is to establish organisational structures to make changes sustainable. In the first phase of the project it became clear that in game-based, citizen-driven science environments, a key apsect is to establish institutional structures for educating children and young people in order to *drive* the development of knowledge-qualified ideas and new models for changing deprived neighbourhoods. It also became clear that developing and supporting organisational structures to handle problems and tasks to tranfer from professional enviroments into schools in deprived neighbourhoods equally important. The developed ideas and models also need to receive professional feedback, as described, where students receive professional opinions on their models for redesigning playgrounds, bike paths or housing in their neighbourhood. Community-driven game activities cannot be claimed as citizen-*driven* if there is not equal emphasis on both sides of this equation. The future phase 2 and 3 of *Cities in Play* will focus both on further understanding how community-driven science gaming environments influence students' learning and agency to further develop institutional structures in schools for educating children and young people to drive change applying game tools, but also on developing so-called cat flaps for submitting ideas to and sharing tasks with various departments of the Copenhagen City Council and for encouraging collaboration, open communication and inclusion in solution making.

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How to Build an Ineffective Serious Game: Worst Practices in Serious Game Design

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Abstract: Learning and teaching through immersive technologies has been an essential research topic in the last decades. Educators are trying to combine difficult topics that usually discourage students from learning with engaging tasks or technologies that will seem more attractive and thus supporting students' participation in learning. On the other hand, the students of the 21st century have been raised in a digital world, and therefore they learn and react differently. Computer games have become an active part of their everyday lives from a very early age, resulting in young people's familiarization with such technologies and their features. Furthermore, computer machines have greatly increased their capacities and capabilities, allowing the installation of game platforms with impressive graphics and special effects. This novelty fosters the usage of such games by users, where they are free to use all of the game's functionalities and immerse themselves in an interactive and attractive environment. These aforementioned benefits pose a significant challenge that is to investigate which elements constitute a successful serious game, what are the ways in which such games can be effectively embedded in the learning process and which are the factors that determine the success components in a game. However, it is essential also, to find out which are the elements that lead to the development of a game with no educational interest or benefits and with no facilitating features for both the teachers and the students. More specifically, this paper includes an analysis of learning principles, mistakes that lead to the non acquisition of long-term memories, and the lack of motivation of learners to keep playing and learning. Further, the paper elaborates on what is the mixture of learning and entertaining elements and features that produce either an unsuccessful or a successful serious game. Moreover, the research study will emphasize on the role of laughter and will highlight the implications of humor and comics for student successful learning. Furthermore, elements of humor such as humor creator and humor receiver will also be approached and discussed. Finally, it is stated how important it is to set achievable and measurable learning objectives and align these to clear learning pathways as well as how to take appropriate feedback regarding learners' performance. The paper also describes all the concepts that are related to the development of an unsuccessful serious game, including the main mistakes that should be avoided. This proposed model will elaborate on the factors that hinder effective serious games development and will highlight that serious games can only support education when they properly link the "fun" elements of computer games with the essential educational elements required for in-depth learning.

Keywords: digital game-based learning, unsuccessful educational games, effective teaching, humor

1. Introduction

According to Prensky (2001) students belonging to the digital society are multi-task individuals who have the capability to accept and send high-speed information. They prefer networking, using graphics and playing games. Furthermore, Prensky (2001) accentuated that this generation, called the 'digital natives' belongs to another culture and speak another language, 'the digital language'. Additionally, based on research conducted by psychologists, sociologist and neurobiology scientist it seems that the structure of their brains is different and as a result they think differently (Prensky, 2001). In order to meet their specific needs, researchers across the world gathered together game designers and experts in pedagogy, conducted game presentations and even attempted to measure the effectiveness of game-based learning (de Freitas and Jarvis, 2007). These authors emphasized the need to consider the curriculum content, the technological content, as well as subject knowledge content, when designing game-based learning. Nevertheless, there are many other expert opinions, highlighting the need to embed a series of pedagogical principles together with the above requirements (Fee, 2009; Bonk and Khoo, 2014). However, there are authors who viewed the effectiveness of digital game-based learning (DGBL) as a puzzle (Tsai, Yu and Hsiao, 2012). As Starkey (2012) emphasized, mobile games are becoming global, and therefore, is this tendency to shift from the traditional style toward a new type of learning, the digital learning. Other authors such as Mumford (1995) argued about the importance of the context of learning, for the assurance of an effective learning. Thus, Mumford (1995) emphasized the role of the environment and the importance of a good practice which is ready to build student engagement and encouragement. This study develops five sections as follows: section one approaches effective teaching and digital game-based learning; section two presents the meaning and the importance of humor and digital comics; section three presents approaches and methodologies for effective game design, section four analyzes the importance of creativity, section five presents critical issues in unsuccessful game design and during the last section mentions describes the conclusions drawn. In the following section, this research will discuss about teaching techniques and the emergence of digital game-based learning.

2. Effective teaching: Digital game-based learning

Effective teaching is a type of teaching that accomplishes its purpose (Kyriacou, 2009). Furthermore, Kyriacou (2009) emphasized that effective teaching supports various types of learning and promotes appropriate learning experiences, which assure the achievement of its aim and objectives. Research conducted by Cattell (Kyriacou, 2009) identified a few characteristics of effective teaching as follows: identity or individuality, knowledge, approach, receptivity and a good sense of humor. It infers that an effective teaching should be receptive to students' learning needs and should have incorporated within comics or elements of humor. However, effective teaching recently, directed its main attention towards teaching and learning, instead of the above mentioned characteristics (Kyriacou, 2009). Thus, most of the studies evaluated effective teaching based on a proposed framework with three variables: context, process and product or learning outcome, whilst other studies suggested the importance of learning outcome only (Kyriacou, 2009). Various models of learning designed by Kyriacou (2009) approach teaching and learning from different points of view such as surface, psychological or pedagogical levels of analysis. Each of these approaches stresses the role of constructs for teaching and learning, just to mention a few: active learning time, motivation, attention, presentation, content, teaching skills, teacher and learner perceptions, behavior and strategies, etc. (Kyriacou, 2009).

Other opinions (Minton, 2005) come and enforce the role of innovation and creativity in teaching. Moreover, Minton (2005) argues that in order to achieve effective teaching, practitioners have to use techniques and strategies, such as demonstrations or simulations, whilst students need to embrace these techniques. Despite of this orientation, there are strong opinions regarding the role and importance of the characteristics of effective teaching, and therefore this study will attempt to consider and discuss this approach. Thus, Neelam, Molstad and Donahue (1999) describe the role of the teacher in creating student centered learning and ensuring effective teaching. They also argue about the role of creativity as an important characteristic of effective teaching and effective learning outcome. Nevertheless, Seidman and Brown (2012) highlighted that teachers lack an effective approach to teaching and learning and often they lack humor. Neelam, Molstad and Donahue (1999) describe humor as a teaching technique and a predictor to learning outcome. Tsai, Yu and Hsiao (2012) find that play is synonymous to game and define this as a human experience. Further, playing digital games is considered a learning experience (Prensky, 2001; Tsai, Yu and Hsiao, 2012). Conform to Tsai, Yu and Hsiao (2012) digital game-based learning (DGBL) called also 'edutainment' or 'serious games' have incorporated the capacity of training. Further, it is inferred from Vandergriff and Fuchs (2012) that humor, embedded within the computer-mediated communication (CMC), is a characteristic of social interaction and an equivalent of face-to-face interaction.

New media technology is revolutionizing the learning and teaching by changing the reading, the writing and traditional communication; in this new context, a new pedagogy is required and teachers need to employ and empower students to use innovative digital tools and techniques (Mills and Levido, 2011). Furthermore, the emergence of e-learning (Fee, 2009) urges teachers to acknowledge the benefits of using e-learning. Additionally, the e-learning enhances the profile of digital game based learning, which is one of the latest teaching techniques. E-learning comprises any content that is transmitted or mediated via technology (Fee, 2009). The components of e-learning are: online learning, web-based learning and computer-based learning. According to this author, the main components of e-learning are the content, technology and learning design. It is suggested that principles of learning should be also considered when designing digital games as e-learning resources. As a result, some authors recommend a certain number of principles to be incorporated when designing learning resources or teaching techniques and suggest ten principles (Bonk and Khoo, 2014). Thus, Bonk and Khoo (2014) recommend ten principles as adequate for effective teaching: good climate, encouragement, curiosity, variety, autonomy, relevance, engagement, tension, vision, interactivity and fun. In the next section, the study will introduce the humor and its meaning and importance.

3. The meaning of humor and the digital comics

Humor was defined as a talent as well as a competence of discovering relationships between things or circumstances in a creative and comical manner and transmitting this meaning to an audience (Inglis, Zach and Kaniel, 2014). Humor was interpreted by Chiarello (2010) as the link between comic support and student learning. Humor is a useful teaching technique ready to create effective teaching environment and to ensure learning outcome (Neelam, Molstad and Donahue, 1999). It is suggested that by incorporating humor within teaching, teachers reduce students' anxiety and stress, assure communication and understanding and also increases student receptiveness (Korobkin, 1988, Proctor, 1984 in: Neelam, Molstad and Donahue, 1999; Chiarello, 2010). Nonetheless, specific guidelines recommend that humor should only be used in appropriate situations in order to support student attention and innovation (Neelam, Molstad and Donahue, 1999).

Humor is also identified as therapeutically and more practitioners are using humor for laughter and mood improvement (Adamle et al., 2007). The same authors highlight that an incorrect and inappropriate use of humor can be harmful for students. However, a good sense of humor is required from teachers in view to ensure effective teaching (Bonk and Khoo, 2014) and more authors (Tuncel and Ayva, 2010) recommend comics as beneficial for effective learning. If the humor is crucial and can be a pedagogical strategy for enhancing student learning experience, it is also true that, misinterpretations of humor or inadequate humor in learning context occur and can produce devastating results for the individuals (Chiarello, 2010). As a consequence, it infers that certain sensitivity to humor creation and use in academic context and in any learning context is required. Elaborated procedure and guidelines might be suggested when using humor within the delivery of learning or just for creating a good classroom climate. Additionally, there is another manner of transmitting humor, such as digital comics. There is a real challenge when designing digital comics for teaching or communication purposes, as the practitioners have to consider the effect of culture and context for the receivers of the message as well as many other principles (Vassilikopoulou et al., 2011).

Bonk and Khoo (2014) argue that learning must be fun. Further, they equal the computer games for learning with fun and creativity. They also indicated the need to embed various learning and teaching principles when designing the digital teaching and learning resources. Additionally, Bonk and Khoo (2014) placed accent on assuring student enjoyment and fun. The meaning of fun can incorporate comics and humor and the design of games and digital learning resources have to be professionally designed. Therefore, in the next section the authors will discuss about the effective/ineffective approaches to game design and worst practices in serious game design.

4. Approaches and methodologies for effective game design

Collaborative Game Based Learning (CGBL) is a learning strategy that focuses on providing features such as dynamic interaction, group communication and work through corresponding tools and materials. This way, students can work together to complete given tasks inside a virtual world. This instructional approach underpins the involvement of students with social processes that they are not familiar with, as well as the introduction to practices and knowledge that will further assist their performance in class (Squire and Jenkins, 2011) with the development of skills such as analysis, problem solving, interpretation and memory activity (Foreman, 2003). Therefore, related literature claims that Game Based Learning (GBL) enables innovative learning mechanisms that trigger cognitive processes during courses.

However, using GBL in demanding courses has always been a challenge for both teachers and students. The investigation of the reasons that these difficulties exist has been the center of interest for many researchers in the last two decades (Chang et al., 2008; Farrow et al., 2008; Galarneau, 2004). The results of the research studies attempt to explain both why learning and teaching demanding courses appears problematic as well as the teaching methods applied in classrooms. Jenkins et al (2002) claims that demanding courses should incorporate learning strategies that foster internal incentives in novice students. These incentives could occur through the increasing feelings of challenge, curiosity, active control and imagination.

Scientific research has shown that a successful learning environment should be interactive, flexible and support personalized learning spaces. The interactivity of the game offers to users dynamic information and incentives for learning (Kerly and Bull, 2007), while adaptability creates conditions for personalized learning based on the characteristics and way of thinking of the user (Baylor and Kim, 2005). This way, learning will be facilitated by improving and maintaining students' interest inside the classroom and creating the appropriate conditions for an easier learning of more complex domains in the future (Cui and Bull, 2005).

Engineering techniques as well as innovative learning designs should be applied to effective learning environments. To achieve this objective, it is necessary to explore the teaching approaches that have been proposed by the relevant literature, as well as the educational tools that have been developed in the context of each identified approach (Ibrahim, & Jaafar, 2009). Moreover, the project should appropriately classify the principles that must be complied during the design of the programming interfaces, meeting the needs of novice students. Additionally, learning techniques for adaptive problem-based learning, game - based learning as well as collaborative learning should be analyzed and combined in the game (Salen, & Zimmerman, 2004).

During the implementation phase of the project, an evaluation plan should be organized that will determine the educational game’s effectiveness. This plan should aim to pinpoint evaluation criteria that will need to be examined by validation pilots, once the system is fully developed and ready for utilization. Such criteria could be “successful task execution frequency”, “successful task execution time”, “number of mistakes”, “frequency of asking explanatory questions” (Campbell et al, 2007) etc. Due to the nature of the environment, it should be intended on identifying appropriate evaluation mechanisms that will sufficiently and objectively assess students’ performance and their general responsiveness towards the game’s environment. During the evaluation phase, the designers should not only focus on the comprehension level of the learning content by the students but also on the skills developed throughout the learning process, such as critical thinking, concept analysis, group work etc. (Del Blanco et al, 2012). The designers should aspire to notice that students will learn in a more effortless and problem – limited manner, while also detecting any arising issues that could be taken into account during the development of a future, updated version of the system. More specifically, there is a variety of challenges that need to be addressed and overcome through continuous observation of the developed environment. Such is the possible disorientation of focus; students, especially at a younger age, might get sidetracked from their duties due to an overly attractive interface that over – immerses them in the game itself rather than focus in the environment’s educational aspect. Therefore, through examination of behaviours, the designers should intend to try to go from “playing with the game” to “learning with the game”. Moreover, teachers should be able to put into practice the identified evaluation techniques that will be in accordance with innovative learning strategies. Thus, they will be able to expand their scope of teaching methodologies and educate themselves whilst evaluating their students (Serrano et al, 2012).

To this end, many universities are trying to develop effective educational games that will foster the learning process. For example, CMX is an educational fully configurable Massive Multiplayer Online Role Playing Game (MMORPG) that has been developed for this purpose, with focus on supporting teaching and learning of computer programming (Malliarakis et al, 2013a). In CMX, a specific mathematical model was developed and implemented that enumerates the different factors that affect the server and eliminates bugs, latencies and errors, for the maximization of the player’s engagement (Malliarakis et al, 2013b). It should be noted that during the evaluation the game was described by the students as a great educational tool that maximizes their creativity and fully supports their engagement and increases their learning (Malliarakis et al, 2014b).

During the development of CMX, the main aspects of educational frameworks that are described from relevant studies have been taken into consideration (Malliarakis et al, 2014a). Thus, CMX supports multiple roles, learning analytics and specific editors for the customization of the educational content and the game-play environment providing unlimited scenarios. Figure provides a representation of all the above concepts that compose the “CMX Programming Prism”, that is a structure that shows how each feature can present a different view of the way the game will be used.

The CMX Programming Prism enables educational game designers to include functionalities in the game that will cover all above entities, leading to a holistic educational game for computer programming. The above figure shows a list of these features that comprise an educational game that supports all phases of education: design, implementation and evaluation.

The analysis of the generated data is important as it can derive informative insights in regards to students’ performance, the game’s performance and other essential features that together construct a successful educational game. To this end, specific metrics are developed in CMX that are recorded during gameplay (Malliarakis et al, 2014c). These metrics regard a) activity data, i.e. when a user logged in the game, how often each user visits the game and plays, b) monitoring data, i.e. how many mistakes each user made during problem solving and c) collaboration data, i.e. messages transmitted and system performance data. All these metrics are inter-connected, and they are shown in the following figure.

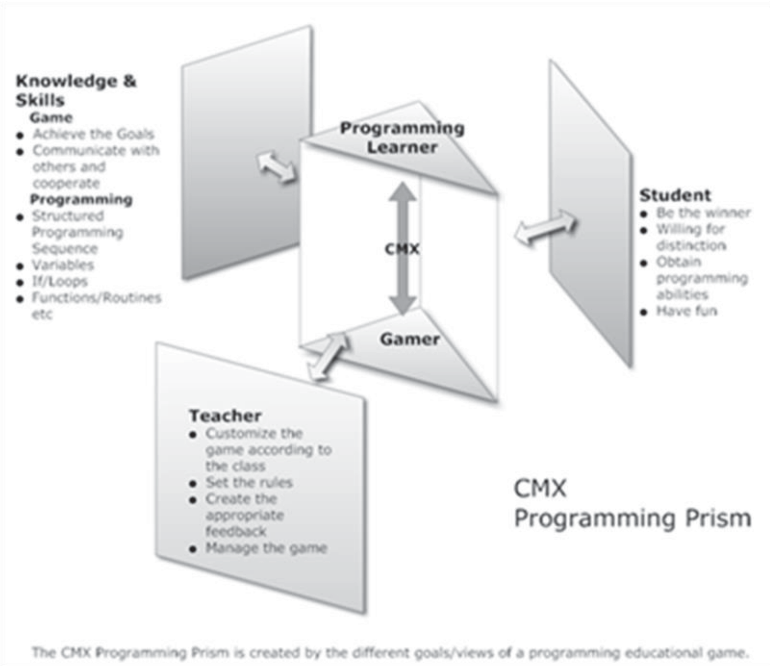

Figure 1: CMX programming prism

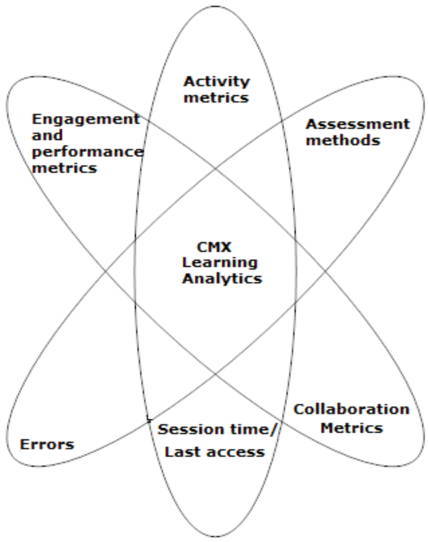

Figure 2: Learning analytics framework in CMX

The system's database records the following variables:

$$\overrightarrow{G_{CS}(t)} = \left\langle S^{cs}(t) \middle| E^{cs}(t) \middle| A^{cs}(t) \middle| F^{cs}(t) \middle| C^{cs}(t) \right\rangle$$

where G_{CS} is the total score that a player receives, $S^{CS}(t)$ is the success score of the player regarding the activities that he/she executed, $E^{CS}(t)$ is the total amount of errors made by the user, $A^{CS}(t)$ represents how active a user is in the game, $F^{CS}(t)$ is the frequency with which a player visits the game and $C^{CS}(t)$ is the index that shows how much each user collaborates with other players. The final score provides teachers with a number that corresponds to each player and indicates the educational score the player gets in the game's progression.

5. Creativity and effective game design

Creativity in learning has been recognized, during the last part of the 20th century and early 21st, to be increasingly significant as a skill to be covered in formal education. Several authors (Protopsaltis et al, 2010, Bellotti et al, 2010) suggest that creativity should be explicitly included as an educational objective into the learning process.

Speaking about creativity people think first about games. It is generally accepted that games (at least the good games) stimulate creativity and a game player must be creative in order to be successful. Games require the players to make decisions, giving them the chance to influence the story and even in part design the world in which the game is played out (Bellotti et al, 2011). Game players are free in selecting different game actions, the game provides a lot of alternatives, contains elements of randomness, game actions selected by the player game can strongly influence on the game process.

Digital learning techniques can be a unique challenge to improve creative learning and inspire creativity in people if using educational computer games, supporting creative thinking and using it for gaining knowledge and mastering new skills.

Educational games can provide an environment for active, critical, often collaborative and creative learning, allowing users to explore methods, concepts and skills rapidly and safely within an environment designed with specific learning components.

Educational computer games will be successful if the learning process is organized in the same way as a game process: on the one hand it provides the certain level of freedom to the learner and on the other hand requires the player responsibility for chosen game actions.

There is a variety of design principles for successful educational games in the literature but only few of them are focused on creativity aspects of learning (Bellotti et al, 2010). Best practices in using educational games for learning show that the following creativity-based learning principles are very important in educational games design:

Inspiration: The learner is motivated to perform self-evaluation and self-regulated learning;

Personification: Each learner builds personal learning strategy and creates his own learning environment while playing;

Gamification: Learning as playing, using game thinking for problem solving.

Following these principles in educational games design improves the quality of the game and makes it successful as such games keep the learner interest while playing the game, motivate him to think and to reflect and thus provide effective learning.

6. Critical issues in unsuccessful game design

In a broad definition educational games can be described as games that are designed and developed to teach someone something about something and that almost any concept that combines gaming and education can be considered as game-based learning (Moreno-Ger et al., 2008). Serious games should be designed for a distinct learning outcomes and not for entertainment only (Kapp, 2012) and have been described as: *"... a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives."* (Zyda, 2005).

Some researchers have described the strong trend to insert educational content into different types of games as a *mad rush* where sound educational principles and game construction theories often have been absent (Gunter, Kenny & Vick, 2008). It has also been discussed whether playing and learning can be seen as intertwined activities supporting knowledge acquisition, or if they are separate activities where the former is limited to a motivator for the latter. Restricting the game playing part to only be a teaser for learning might also risk the motivation effect and also amongst researchers that consider gaming as a strong motivational factor there exist doubts on how game mechanisms are implemented in learning games (Sigurdardottir, 2012).

The phenomenon when learning content and game concepts are carelessly mixed is called *"Shavian reversals"*, a term that was coined by Seymour Papert (1998) in an article where he compares ill-designed educational games with offspring has inherited the worst characteristics of both parents. The important warning in Papert's article is that learning games should not be trivialised and made too easy and if the challenge is missing in a game, the thrill is gone as well. Another identified factor is that the game flow disappears if the learning content overshadows the gameplay (Peirce, Conlan & Wade, 2008). If the game designer tends to prioritise learning outcomes to game flow and narration serious games tend to be perceived as too serious and not particularly motivational or enjoyable (Brusse, Neijens & Smit, 2010).

The crucial factors for game flow are depending on the game type (Sweetser & Wyeth, 2005) but game designers always have to be careful with every specific game's design details to achive joyful gaming (Papert, 1998). Some identified critical issues for gaming usability are the game interface, the game mechanics, and the gameplay (Sweetser & Wyeth, 2005). A game's interface consists of controls for user input and how feedback and game results are provided. Game mechanics are the rules for the player's interaction with the game and its gameplay (Federoff, 2002). Game mechanics should also be constructed as something that connects players' actions with the purpose of the game and its main challenges (Sicart, 2008).

7. Conclusions

Learning and teaching through immersive technologies has been an ongoing research topic in the last decades. Educators are trying to combine difficult topics that usually discourage students from learning with engaging tasks or technologies that will seem more attractive and thus supporting students' participation in learning. On the other hand, the students of the 21st century have been raised in a digital world, and therefore they learn and react differently. Computer games have become an active part of their everyday lives from a very early age, resulting in young people's familiarization with such technologies and their features.

To this end, in this paper we described the main features that compose an ineffective game through different views and by analyzing the crucial factors regarding the engagement and the learning content of a successful educational game. More specifically these factors are a mix that should be carefully considered either while the game is designed or while the game is utilized in an educational course. For example a game should allow collaboration and interactivity between the students during activities execution as well as features personalized to each students' particular needs. Furthermore, educational game should allow learning processed that foster critical thinking and problem solving, as well as create a fun, creative, humorous and encouraging environment that will motivate students to increase their knowledge while also enjoying themselves. Finally, these games should support configuration features for the teachers such as the ability to edit the environment, adapt the learning content and activities and monitor the learning experience through learning analytic tools.

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A Tangible Digital Installation in the Classroom: Role Play and Autistic Children

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Abstract: This paper describes a three weeks study involving 15 children affected by autism spectrum disorders (9-12 years old) in a primary Danish school. The aim of the study was to support the class teachers in assessing the benefits of game-based learning with respect to their main two challenges: facilitating the emergence of imagination and conceptual thinking, and managing the interplay between cooperation and competition. This cooperation originates from one of the teachers' interest in MicroCulture, a digital and tangible installation earlier created by the authors and aimed at bridging history learning across museums and schools. The design of MicroCulture focused on urban development seen as a social process; in order to cover children's multiple play modalities and support their interaction with guides and teachers, MicroCulture offers exploratory gameplay, with no predefined final goal and no score. At Aadal school the teachers introduced MicroCulture to the children and used it to discuss specific aspects of the life of the Vikings, and allowing them to play in small groups. The data were gathered through ethnographic observations, interaction analysis of video recordings and interviews with some of the school's teachers. We found that through mediated play and teacher's facilitation, children occasionally engaged in interactions leading to conceptual thinking, cooperation, and forms of role play. According to the teachers such occurrences represented a valuable achievement in the development of her classes, offering opportunities to discuss and explore with the children different forms of social interaction. Difficulties were encountered as the teachers had to find ways of supporting the children, strategically shifting between guidance and responsibility transfer, moderate children interaction towards cooperation while it often could resulted in conflicts. These results are contrasted against early findings concerning MicroCulture and museum-going pupils without autism. Our findings also show that MicroCulture will require further redesign, to better accommodate teachers and autistic children's needs.

Keywords: digital games based learning, facilitation, autism, role play, history

1. Introduction and motivation

An increasing number of studies has been dedicated to the design and evaluation of digital technologies targeted at supporting children affected by autism spectrum disorders (ASD for short) (Aresti-Bartolome and Garcia-Zapirain 2014). Differently from previous studies, which focus on supporting children in developing their skills in literacy and social interaction (Ploog et al. 2013), this paper discusses how technology can help teachers covering specific subjects, e.g. history. This particular study emerged from the interest expressed by a primary school teacher from Aadal School in Denmark, who works with classes of children affected by ASD. Her concern was to find proper support to help her pupils dealing with conceptual thinking and with the content of the subjects of their school curriculum.

The adopted technology is called MicroCulture, a tangible, interactive installation created prior to this study, aiming at bridging learning of history across museums and schools (Marchetti 2013). MicroCulture is a digital simulation of urban development, seen as a social process that is mapped on tangible interaction. In order to cover children's multiple play modalities and support their interaction with guides and teachers, MicroCulture offers exploratory gameplay, with no predefined final goal and no score.

Previous work with MicroCulture (Marchetti 2013, Marchetti and Valente 2013) showed how children without autism, visiting a Viking museum in Ribe (Denmak), could engage in social interactions and role play; in those evaluations adults (the museum guides) supported the children in understanding the technical functionality of MicroCulture and its historical meaning. A similar situation was setup for the two weeks evaluation conducted at Aadal School, where the teachers were given full control on the MicroCulture installation. In this way we could evaluate if the technology was usable for the teachers from a technical and pedagogical perspective, while evaluating how MicroCulture affected children's social interaction and their learning.

The rest of the paper presents related work (section 2), then the evaluation and the methods adopted in the collection and analysis of data (section 3). Section 4 contains a discussion of the findings, and the last section reports our conclusions.

2. Related work

An increasing number of studies have been dedicated to the design of technologies targeted at children affected by ASD. At the same time an increasing number of children are diagnosed with ASD, partly because a greater awareness and better diagnostic practices emerged about the condition, and partly because of a constant redefinition of what autism means (Aresti-Bartolome and Garcia-Zapirain 2014, Tartaro and Cassell 2007). In general different forms of autism can be found, which can affect individuals in different ways and more or less severely. However, all forms of autism hinder individuals in communicating and identifying emotions in others, causing difficulties in developing relationships and in playing with peers (Ploog et al. 2013). At the same time ASD are also related to difficulties in using imagination and in developing creativity, leading affected individuals to repetitive behaviours (Aresti-Bartolome and Garcia-Zapirain 2014). According to some studies there is a risk that digital technologies might reinforce the typical behaviours of autistic children, contributing to their social isolation and to their repetitive behaviour. Authors showing a more positive attitude (Aresti-Bartolome and Garcia-Zapirain 2014, Tartaro and Cassell 2007) argue that properly developed and contextualised technologies can instead support children in compensating for their difficulties, so that they can practice their social and learning skills with less effort and prepare to better face real life situations.

The technologies developed to support children affected by ASD focus on their weaknesses and/or strength, to help them gaining skills in social interaction, communication, literacy, and creativity. For example, a study conducted by Madsen et al. (2008) specifically targets social interaction skills and presents *Emotion Bubbles,* a mobile application to help autistic children in processing the facial expressions of their friends and their own, in real time. Based on recognition of movements of the head and the face, *Emotion Bubbles* can infer six states of mind, such as: *"agreeing, concentrating, disagreeing, interested, thinking and confused"* (Madsen et al. 2013, p. 3). The first three are associated to positive emotions as they indicate that a conversation is proceeding, the last three could be a sign that the speaker might *"want to reiterate or rephrase a previous point in order to make sure the listener understands"* (Madsen et al. 2013, p. 3). Each of the six states was assigned a colored bubble, and its intensity is measured numerically and mapped on the radius of the bubble. According to the authors, testing with *Emotion Bubbles* revealed that the interface effectively supported children in becoming more interested in recognizing specific states and in trying to elicit a particular state in their mates, as the children were trying to increase the size of the bubbles related to positive states.

In another project, Tartaro and Cassell (2007) have developed PAT (Play and Tell) a virtual peer for children affected by autism targeted at what they call the *"triad of impairments"* defining ASD, which includes: social skills, imagination, and language. The system is aimed at providing children with an authorable, life-size, full-body virtual peer for collaborative storytelling and social interaction. This study is based on the notion that social interaction provides scaffolding to learning and that by hindering children's social interaction ASD also limits their access to learning opportunities. Results show that for some children PAT is intuitive and motivates them in tight social interactions that would otherwise be difficult.

Despite the many studies aimed at supporting children with ASD, there are still open issues, for instance according to Aresti-Bartolome and Garcia-Zapirain (2014) most studies address individuals and not groups; moreover, such studies present evaluations of pilot studies involving a limited number of participants over a short time span, with the risk of not producing reliable data. Several studies also take a generic approach to ASD regardless of specific conditions and their severity (Aresti-Bartolome and Garcia-Zapirain 2014). This is confirmed by Ploog et al. (2013), who claims that different conditions of ASD do not affect speech in the same way, for instance individuals affected by low-functioning autism might *"lack functional speech entirely"*, while individuals affected by Asperger Syndrome might have *"excellent language skills"* (Ploog et al. 2013, p. 301). For this reason Ploog et al. (2013) advise that technologies addressed at supporting individuals affected by autism should be customizable by the teachers according to the children's specific needs. Finally, we noticed that as most studies focus on social interaction, creativity, and literacy, but do not explicitly support children in acquiring the knowledge from their curricular subjects. Hence, a need can be identified in investigating how technologies could support children affected by ASD in learning their school subjects, as confirmed by teachers at Aadal school, who saw an opportunity in our technology even though it was developed without autism in mind.

3. The study

In a previous study about playful e-learning in the museum, a digital installation called MicroCulture was designed through a participatory design process involving circa 25 children from 9 to 12 years old, in cooperation with the Viking museum in Ribe, Denmark (Marchetti 2013). MicroCulture was created as a playful simulation, in the terms of Simon (1996), to enable children imagining how it could have felt to participate in urban development in the Viking Age. The gameplay of MicroCulture specifically focuses on the role of political authority and placement of infrastructures on the territory (Marchetti 2013); these are seen in archaeological literature as two fundamental and intertwined factors in urban development (Jensen 1991). The children are supposed to play as if they were kings or landlords and increase the population of the simulated settlement placing infrastructures. At the same time the gameplay does not impose specific rules or goals, as the children are supposed to explore how to play. As an installation, MicroCulture is composed of: a laptop, a flat TV screen oriented horizontally, and a webcam placed above the screen (as visible in Figure 1 on the right). A basic set of 4 paper tangibles are provided, which the players can use to place infrastructures on the landscape: bridges, wooden paved roads, market place lots and round ramparts (Figure 1 on the left). All infrastructures disappear after circa 1 minute of real-time; this was decided to remind children that urban development requires commitment from the political authorities.

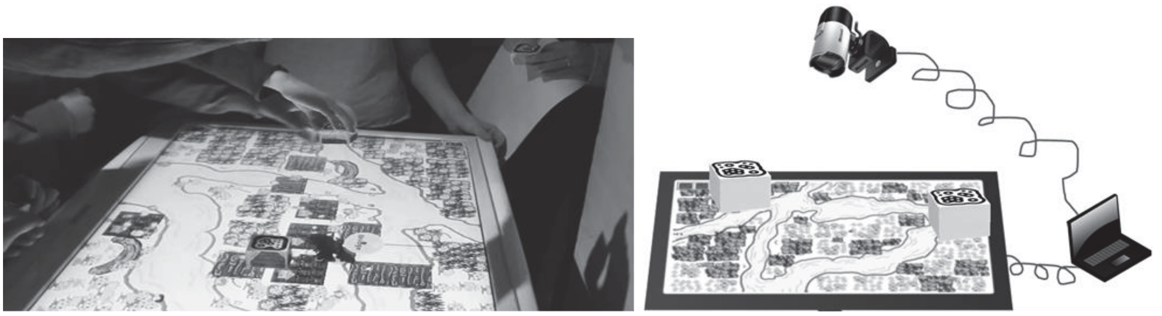

Figure 1 (left): (Left) MicroCulture during the final test. Children are placing infrastructures on the settlement playing with the given tangibles. (Right) A webcam looks down at the game board, captures markers on paper tangibles; the board is in fact a flat television placed horizontally. A laptop runs the game and outputs on the television screen

This study was conducted in cooperation with Aadal primary school in Esbjerg, Denmark, where a separate building is dedicated to special classes for children affected by ASD. In particular, Bodil (the teacher who approached us to start the study) saw MicroCulture as an opportunity to try out how digital technologies could support children during her history classes. Our focus was to explore the role of digital technologies within history learning bridging museum and school learning practices.

During initial meetings, Bodil presented us her challenges when supporting children in grasping abstract concepts in their curricular subjects such as history, mathematics and natural history. These challenges are related to children’s difficulty with imagination and communication, with each other and with the teacher, and are commonly acknowledged issues in the education of autistic children (Ploog et al. 2013). In response to these issues, the school adopts an experiential approach based on Vygotsky (1978), engaging the children in practical activities such as: construction of artefacts, playing social games related to the subject at hand, and walks outside. Children at Aadal school have difficulties in interacting socially and in gaining self-esteem in relation to their learning, but individual responses vary: some children might become shy and reserved, hindering teachers in their effort of supporting them, while others might become aggressive and difficult to handle, for the teachers as well as for their classmates. In this respect, play was seen by the teachers as an opportunity for joint social interaction and grasping of historical knowledge.

The evaluation of MicroCulture was conducted through a 3-week history module targeted at 10-12 years old autistic children, and included 15 individuals. During the first week the children were introduced to Viking history through light lectures and creative activities, such as building Viking houses with natural materials like wood, turf and grass. These activities were coordinated by the teachers and were aimed at stimulating children's imagination towards settlement culture during the Viking Age. During the following 2 weeks the teachers introduced MicroCulture to the children as part of their lectures, to discuss specific aspects of the life of the Vikings, by demonstrating settlement dynamics and other abstract concepts to the children, allowing the children to play with it in small, supervised groups. This evaluation focused on how the use of MicroCulture could support the children's learning process, in relation to the emergence of conceptual thinking and social interaction with each other and the teachers. At the same time we wanted to evaluate if the prototype was useful to the teachers, in terms of usability and pedagogical value.

The evaluation was conducted through video ethnography and in situ observations (Pink 2006). The main challenge was to minimize the risk of creating disturbances for the children, who have issues with meeting new people. Hence, we agreed with the school in paying a few visits in the beginning of the history module, in which we observed the teachers and children in action, and afterwards we gathered three main recordings and observations of how the teachers and the children interacted with MicroCulture (Figure 2). Because of these restrictions we were able to directly observe and record only 7 out of 15 children. However, indirect data was gathered by a conclusive interview that was conducted with Bodil and the head of the school.

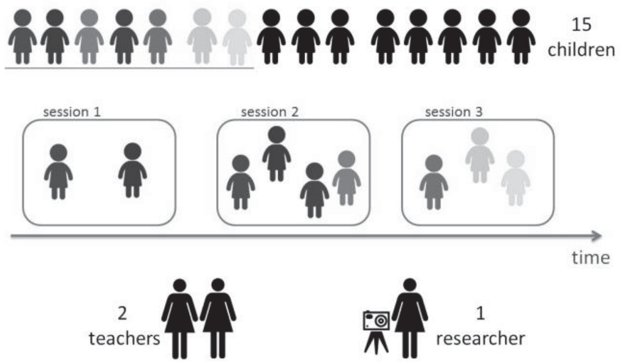

Figure 2: To our evaluation participated 15 ASD children and 2 teachers. We were also present to record at three sessions, and later to interview Bodil and the head of the school.

Visual ethnography and observations were chosen as they enable researchers to gather valuable data without altering the context and activities of the users, which according to the teachers was a vital requirement not to distress their children (Ploog et al. 2012). Gathering of video material secured that we could analyse our data outside the school and go back to them anytime without having to involve the children again. The videos were analysed according to the principles of visual ethnography (Pink 2006) and interaction analysis (Jordan and Henderson 1995), focusing on the verbal interplay among the children, their tone of voice and physical gestures. At the same time we paid attention to how the teachers introduced the installation to the children, in order to define what they found useful and new design requirements.

4. Findings and discussion

MicroCulture was received positively and the teachers saw good potential in adopting similar technologies in their teaching. From our recordings it emerges that through mediated play and teacher's facilitation, the children were in few occurrences engaging in interactions that could lead towards conceptual thinking and potential cooperation through a rough form of role play, in which the historical content of MicroCulture was contextualised within their social interaction. The teachers considered such occurrences a valuable achievement in the development of the classes, offering opportunities to explore different forms of social interaction with the children while discussing Viking Age history.

Previous results from the evaluation of MicroCulture at Ribe museum, involving children without autism suggest that children play evolved through 4 main stages (Marchetti 2013):

- technical - understand how to play with the installation
- collaborative - focus on the content of the installation and explore together how to grow a settlement, sharing the tangibles
- role play - start acting as if they were characters in the simulation, playing the role of kings or landlords
- competitive play - a mature stage of role play; children act as competitive landlords, teasing each other verbally and through use of tangibles

During the evaluation conducted at Aadal school significant differences emerged in the way autistic children and their teachers related to the installation. For instance, Bodil would begin demonstrating how the MicroCulture works and the children would follow her and start playing. In this technical stage the children would try to discover the installation on their own or involve other children and the teacher, their main reference during this stage. A 10-year old boy was especially keen on attracting the teacher's attention by teasing her (as in Figure 3), he would touch her arm or place his hand in front of the webcam while she was placing her tangible on the screen to demonstrate how the installation worked. The teacher welcomed his attempts and tried to involve him more in playing.

Figure 3: The boy in the striped shirt is teasing the teacher

After the first stage the children got more focused on what happened on the screen and explored the installation, engaging in actual play. In our previous museum test children attached themselves with particular area of the simulation, but explored the functions of the different tangibles. Instead autistic children explored the whole landscape or focused on the central island (visible in Figure 1 on the right), but used only one tangible. It could be interesting to explore further if autistic children's behaviour was a way to avoid uncomfortable social exchanges of the tangibles, or merely an expression of repetitive behaviour (Ploog et al. 2012).

We found that the Aadal school children used two main strategies to engage in interaction: the first was commenting on what happened in the simulation and stating the next planned action, the second was to try to coordinate an action with the other children towards a common goal, involving other children in their narrative. In general the younger children were more active in playing, but tended not to establish eye contact with each other, while the older looked and talked at each other more often. The children who adopted the second strategy addressed more clearly other children, however not always successfully: in one successful example from our recordings a boy attempts to involve other two boys in his action and explains it to them (Figure 4). The teacher tended not to interfere so that the children could interact freely, however, at that point she commented smiling: "Good M. and R., it is nice that you were trying to make a story!". This second strategy resembles the collaborative stage in the museum children, and can occasionally express forms of role play. We could also see that teachers were happy and encouraging when this second strategy emerged. The teacher also commented to help the children interpreting what was going on in their game in relation to historical meaning. For instance in one case the children noticed that the agents in the simulation died, especially children, hence the children and Bodil engaged in discussing demographical trends in the Viking Age, issues with diseases and lack of food (Figure 5).

Figure 4: M. successfully involves R. into his play

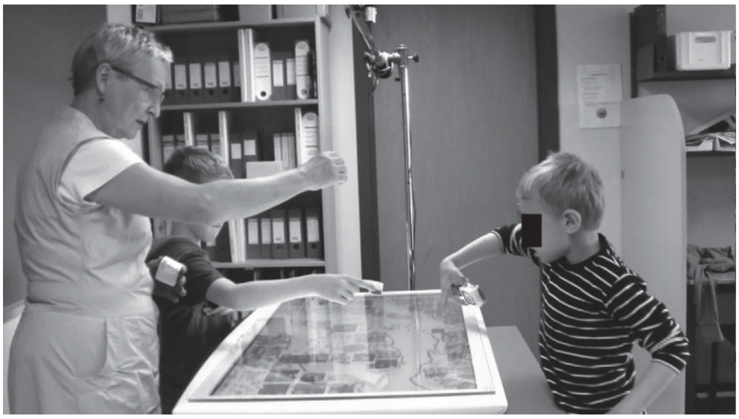

Figure 5: Boys interacting, discussing demographic trends in the Viking Age with Bodil

In other cases similar cooperation attempts were unsuccessful. For example two children around 12 years of age experienced a conflict: the boy tried to engage the girl in increasing the size of the population and using more tangibles, while she kept using the bridge tangible, placing bridges all over the landscape. The situation became serious when he started to yell at her: “You are killing them T., You are killing them!” referring to the agents in the simulated settlement, making violent gestures with his arms (Figure 6). The teacher intervened several times to tell the boy that she was free to play as she wanted and that he had to interact differently with her. The girl simply continued to play at making bridges, while the teacher attempted to make them play together quietly. Her attempts were unsuccessful and eventually she was forced to send the boy to another room to calm down.

Figure 6: The girl keeps making new bridges, while the boy is upset. Bodil intervenes to calm him down

4.1 The role of the teachers in the museum and in school

In both evaluations, our museum tests and at Aadal school, the aspect of guidance and responsibility transfer was a key factor in the children’s experience. Sociocultural theories about learning in children without ASD argue that guidance is a necessity as soon as children reach their *zone of proximal development* (Rogoff 1990, Vygotsky 1978), defined as the boundary zone between the knowledge that children already have and the new knowledge that they have to acquire. However, children who are granted independence at early stages of their learning, become more secure in mastering the activity at hand sooner than children who are guided for longer time (Rogoff 1990). In this sense it is vital that teachers or other adults facilitating children in their learning are responsive to the children needs and progresses, in order to perform a proper responsibility transfer.

In our previous study museum guides provided guidance mainly to explain to the children the technical functionalities of MicroCulture and its historical meaning, instead at Aadal school teachers provided more complex guidance, dealing with:

- Instructing children in the use of simulation, explain the links with history
- Coordinate children actions so to avoid unwanted conflicts
- Stimulate their imagination and encourage them in role play

- Show the children how they could play
- Evaluate when to perform responsibility transfer and be ready to get back in control

Some of these concerns are not easily reconcilable; in fact difficulties were encountered as the teachers had to find ways of supporting the children in pursuing learning and social interaction, strategically shifting between guidance and responsibility transfer, in order to channel children interaction towards a peaceful cooperation, while often children interaction would have resulted in conflicts. When a teacher intervenes, however, she might unwillingly spoil the opportunity for the children in engaging in role play, as it actually happened in this study according to what reported by Bodil in our interview. Interestingly, this situation partially contradicts current literature, claiming that computers can better support the children while adults caused more instances of maladaptive behaviors (Ploog et al. 2012). In this study we found that introduction of new technology implies a learning process also for the teachers, who have to become able to master new tools but also potentially re-assess and adapt their facilitation style.

In our previous work (Marchetti 2013) we describe the facilitation of the museum guides also in relation to its effect on children's play. For example, the two guides had different facilitation styles: one was intervening throughout the session, instructing and commenting on children actions, while the second was more prone to perform early responsibility transfer and moved on one side in order to leave the children enjoy their play on their own. As the children engaged in role play, acting as landlords developing their settlement, the guides were differently included in the children's play. The first guide seemed to play the role of the king, coordinating the actions of his noblemen, the second instead played a role closer to that of a nobleman giving advice to the kings (Marchetti 2013). By contrast, the role of the teachers at Aadal school appeared limited to that of the leading king, who had to secure that conditions for cooperation are secured among potentially competing noblemen.

MicroCulture does not impose any specific rule of play to the children (a form of *openness*) and it was specifically made to mediate between children and adults (Marchetti and Valente 2013). In our previous tests this openness enabled the children to explore how to play on their own and the guides to interact with the children according to their needs and emerging interests. On the other hand, according to Bodil more precise instructions and guidance are needed in order to support her pupils in engaging in role play. In future studies we should consider embedding guidelines within the installation, perhaps explicitly showing possible ways of playing with MicroCulture, show-casing potential roles for teachers and children. We could also provide options for the teacher to customise MicroCulture according to specific needs (as suggested in Ploog et al. 2012). In our final interview, Bodil concluded that she sees great potential for the use of this and similar technologies in her teaching as: "this kind of teaching makes history alive for the children." She also added that she can easily incorporate MicroCulture in her teaching, as she can either "stand up and explain things to the children, but also let them play on their own." However, time is a critical factor with her pupils, and she proposed having the technology for four months or more at the school, so that all the children would have enough time to get confident with it and be more significantly affected.

5. Conclusion

In general we can say that the Aadal school children seemed to enjoy playing with MicroCulture and elements of cooperation, role play, and competition emerged in their play. In previous evaluations cooperation and role play were common and competition represented a mature form of play, in which the children explored further how they could interact with the installation and with each other. Instead the children at the Aadal school tended to play on their own, only occasionally engaging in social forms of role play and cooperation. Interestingly, the children were able to reach the cooperation and role-play stages, but in a somewhat delicate and transient way: attempts at cooperation could often end in conflicts, especially when one child unsuccessfully tried to engage other children in achieving a common goal. The final, competitive stage emerged only occasionally in groups of children without autism, and was not observed in this study. However, the autistic children in this study showed various degrees of competitiveness as part of their cooperation and role-play. The four stages identified for children playing MicroCulture are still relevant here, with a more complex, less sequential interplay between stage two and three, compared than our previous findings. Despite the difficulties the children encountered in their interaction, MicroCulture has been evaluated positively by teachers, as it fits well with their approach to teaching and it provided condition for social interaction and historical discussions among children and teachers.

The main weakness of our study was that our technology was not developed with autism in mind, so that it did not address the specific issues caused by the different forms of autism, as advised by literature (Aresti-Bartolome and Garcia-Zapirain 2014, Ploog et al. 2012). Furthermore, the study involved just 15 pupils which is not a sample large in many respects, but corresponds to the total amount of autistic children educated at Aadal school. Hence, our evaluation was as inclusive as possible and of a realistic size within the context of autistic classes in Danish primary education. Moreover, since MicroCulture affords group interaction, possibly up to 8 participants with a couple of facilitators, it was possible to observe small groups playing and not only isolated individuals as in other studies (Aresti-Bartolome and Garcia-Zapirain 2014).

Further studies are needed in order to investigate how digital and tangible installations like MicroCulture can properly support autistic children learning in social contexts and at the same time support the teachers in their task as facilitators. From a methodological point of view, improving the design of MicroCulture involving teachers and children in autistic classes could require the adoption of novel methods in the area of participatory design.

Acknowledgements

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Manuskills: A DGBL Toolkit to Raise Young People's Awareness About Manufacturing

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Abstract: Manuskills is a EU funded project (FP7 609147) that aims at studying the use of enhanced ICT-based technologies and training methodologies to facilitate an increase of young talents' interest in manufacturing and to support their training of new manufacturing skills (http://www.manuskills.org/). The conceptual framework of the project describes in detail Manuskills' learning objectives and the process through which they are achieved. In detail, Manuskills aims at the realization of three different levels of conceptual understanding: awareness, knowledge and application. The three abovementioned levels are also mapped with Bloom's Taxonomy of Learning Objectives. Nevertheless, identified as the main goal of the project is to raise awareness about manufacturing. In order to achieve this goal, a number of cutting-edge ICT educational tools and corresponding methods are employed, in the form of serious games and teaching factory. According to Rebolledo-Mendez et al. (2009), "the term serious game is used for game-based situations used for non-leisure purposes or serious applications such as learning and training". The approach followed by Manuskills for the integration of serious games into the learning process complies with the third approach described by Van Eck (2006). In more detail, the employed serious games constitute the result of the collaboration between educators and developers. Moreover, an important aspect that was taken into account during the design and the development of the games was the integration of pedagogical principles, so that the awareness-raising, leading to behavioural change, could be integrated into the game. The literature shows that it is only until recently that serious games are used in order to develop awareness concerning several social issues. Furthermore, previously conducted research indicate a link between game-based learning and behavioural change (de Freitas, 2009, in Rebolledo-Mendez et al 2009). The current paper aims at presenting the DGBL (Digital Game-Based Learning) approach followed by Manuskills project, primarily in order to raise young talents' awareness and secondarily in order to attract their interest about concepts around manufacturing. The six different Manuskills' delivery mechanisms are designed around different manufacturing related concepts. We are going to present our route so far in the project and our vision towards the creation of awareness around manufacturing-related concepts on young people through the use of serious games.

Keywords: Manuskills, serious games, awareness, manufacturing, DGBL

1. Introduction

The current paper presents the EU funded project (FP7 609147) "Manuskills". The main aim of the project is the study of advanced ICT-based technologies and training methodologies to the end of the resolution of the increasing problem of the lack of young talents in Manufacturing. Towards achieving this goal, a wide range of different technologies and distribution channels have been taken into account (e.g. serious games, teaching factory and social media). For a more detailed representation of the Manuskills' objectives, the aforementioned goals are linked to the project's identified target groups and consequently result to the following:

- To understand and provide guidelines on how to increase the Teenagers' Awareness and Interest in Manufacturing.
- To understand and provide guidelines on how to improve the Young Adults' Awareness, Interest and Application of Manufacturing.

To succeed in this direction, ManuSkills will try to present and explain the latest trends in Manufacturing (e.g. digitalization, virtualization, servitization) and consequently outline its actual modern features, contributing to the creation of a more authentic perception of what a Factory of Future is and will be.

2. Manuskills' conceptual framework

A key factor for the development of Manuskills initiative was the need of tackling the uprising Skills Gap Phenomenon, which is currently experienced by many manufacturing companies world widely and is expected to aggravate in the near future. As a result, the younger generation has lost interest in manufacturing or lacks realistic information regarding its real meaning and contribution. The aforementioned problem is partially caused due to the utilization of "obsolete" methods and tools in all levels of education. Therefore, ManuSkills' main goal is to test the advantages of cutting-edge ICT-based tools for the increase of young talents' awareness towards the most important concepts and modules of the industrial world.

ManuSkills' vision will go beyond just the raising of awareness, to the development of learners' understanding for specific manufacturing concepts and even touch the area of application and training of specific manufacturing skills, leveraging the experiential learning model. This implies a deeper engagement and knowledge compared to awareness.

The three levels that Manuskills' wishes to achieve are inspired and mapped with Bloom's Taxonomy of Learning Objectives (Bloom, 1956).

As depicted in Figure 1, ManuSkills Learning Objectives are mapped accordingly to the described levels and therefore reshape Bloom's Taxonomy into only three levels, namely: awareness (remember), knowledge (understand) and application (apply, analyse, evaluate, and create).

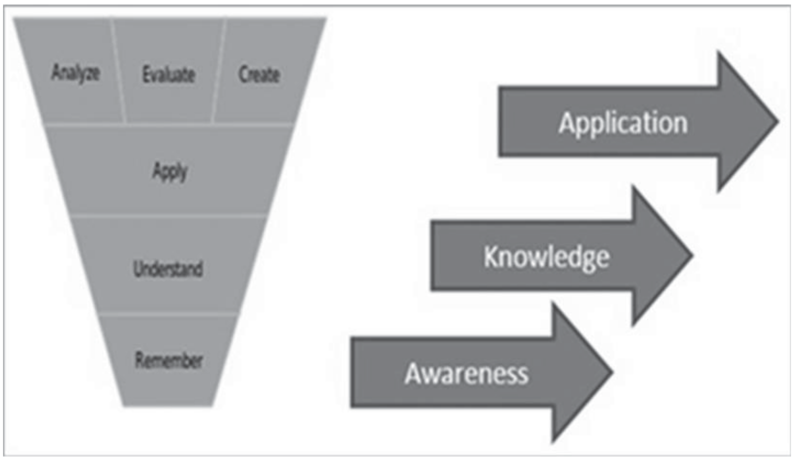

Figure 1: Bloom's revised taxonomy mapped to ManuSkills' Learning Objectives

On a different axis, interest, i.e. the feeling of wanting to learn more about something or get involved in it, due to curiosity or attention excitement, consists an additional objective for ManuSkills. Interest is not considered as a separate learning objective, but as a facilitator towards learning. Most of the times, awareness and knowledge are not sufficient in order to attract someone to a certain direction. This is the reason why Manuskills utilises the concept of interest as a way of attracting young people in the world of manufacturing, since interest leads to motivation increase.

The age groups that find themselves in the center of the project's research lens are, in general, teenagers and young adults. The reason for this choice is that these groups represent the most important beneficiaries of STEM and manufacturing education. By teenagers we refer to students from 10-19 years old and by "Young adults" we refer to the whole range of university students, i.e. Bachelor, Master.

The rationale closely related to Manuskill's learning model is that every developed Experiment targets a certain learning objective corresponding to a specific age group and thus presenting a certain level of difficulty, as depicted in the spiral form of Figure 2. More specifically, for what would be considered as early teenagers the main learning objective would be to raise awareness regarding a given skill set and thus the level of difficulty of the experience/learning plan is the lowest one (L1). Accordingly, the second age group, i.e. teenagers (approximately from 14 to 18 years old) are expected to go a step beyond awareness and touch the level of knowledge (at least to a basic extent) through their interaction with Experiments of medium difficulty (L2). Finally, regarding the oldest age group, i.e. young adults (above 18 years old), we aim to achieve the learning objective of application, that is applying already acquired knowledge regarding a specific skill set in a new situation. In this case the Experiments presented are of the highest difficulty level (L3). The spiral shape of the model reveals its iterative nature, according to which content actually remains the same and is reused and adapted to the different target groups.

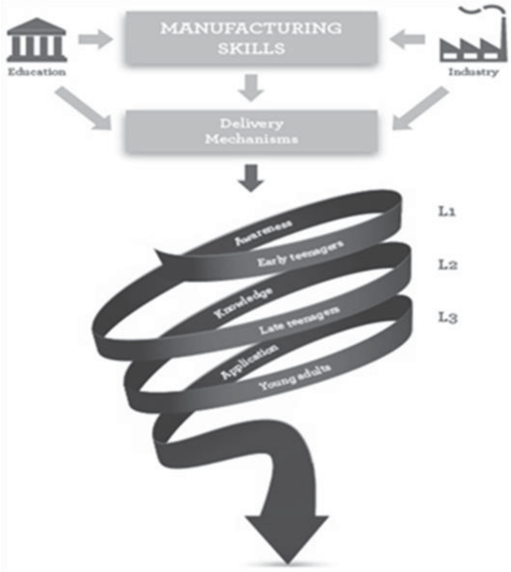

Figure 2: ManuSkills conceptual framework

3. Manuskill's pedagogical background

The principal pedagogical theory underlying the whole project -and consequently its activities- is Constructivism. In contrast to the traditional view of education, as a process involving the transmission of knowledge from teachers to students, the constructivist view supports that learning occurs through a process, in which learners play active roles in constructing the set of conceptual structures. All Manuskills' activities and tools, destined for student engagement, are rich in knowledge construction. In addition, following the principles of constructivism, the role of the teacher is advised to consist to the facilitation of the procedure and guidance of the students. It should be mentioned that there are various types of constructivism such as radical, social, physical, evolutionary, post-modern and information-processing (Karagiorgi and Symeou, 2005).

Various approaches in pedagogy derive from constructivist theory. One of the main approaches leveraged by Manuskills is Game-based learning, which compromises a focus on achieving the particular objectives of an educational concept through game play. A more detailed description of the approach places players in a continuous situation of attempting to solve problems throughout the learning session.

In the case of computer game players (Digital Game-based Learning), to continue their learning and gaming, they should apply their own strategies to solve the problems in the game. In Game-based Learning where they both study and play, learning strategies and gaming strategies are the same phenomenon seen from different perspectives (Kim, Park and Baek, 2009). For the adoption of Game-based Learning approach in educational settings, games are more likely to be utilised if they consist a source of inspiration, or if the link to the curriculum is clearly stated, since teachers play an important role in the adoption and effective use of this approach (Bourgonjon et al., 2013).

The review of relevant literature indicates that there is a link between Game-based Learning and behavioral change (Freitas and Neumann, 2009). Serious games designers and developers should consider pedagogical principles to inform the design of their games so that learning or awareness-raising, leading to behavioural change for example, can be integrated into the game (Rebolledo-Mendez et al., 2009). By including pedagogical strategies, in the form of structured game-based learning activities, it would enable the evaluation of both the learning and the degree of awareness achieved by individual players. Finally, it should be mentioned that the use of pedagogies in computer-based education has yielded positive results in learning gains (Luckin, 1998, Papert, 1983 in Rebolledo-Mendez et al., 2009).

4. Manuskills' approach

One of the main reasons for the low effectiveness and motivation of STEM education in secondary schools and engineering studies in higher education is considered to be the fact that teachers employ consolidated methods, techniques and tools, that are not appropriate for the needs and standards of today's education. In the frame of achieving Manuskills' Learning Objectives, several delivery mechanisms -in ManuSkills they stand for cutting-edge ICT educational tools and the corresponding methods- were developed, so that the delivery of a course or even a concept regarding STEM and/or manufacturing education can be succeeded in a proper and contemporary frame.

The main tool, towards this goal, is ManuSkills Platform, which is an educational channel through which both students and teachers can get involved in a rich educational experience. The main components of the platform are generally mentioned as Experiments. These experiments have a dual nature and consequently consist of both an ICT based delivery mechanism and a pedagogical scenario.

Each one of Manuskills Experiments employs a different delivery mechanism, like a serious game or a virtual reality application etc. The second part of each Manuskills Experiment is the Pedagogical Scenario, which is a technology supported learning plan whose special value lies on the fact that it provides the documentation of all the aspects of the designed educational activity. The Pedagogical Scenario addresses aspects of the activity such as the epistemology of the domain, the social orchestration, the duration and the role and use of the tool (Yiannoutsou and Kynigos, 2013). For example, following Manuskills' approach, if a teacher wishes to teach a specific engineering/manufacturing skill (set), he/she could design a plan consisting of different steps, which leverages videos, presentations, serious games or simulations to present a concept from different angles.

The experiments developed under Manuskills' framework aim at raising awareness and/or learning effectiveness by allowing the user/learner to have easy and direct access to their contents. Manuskills' Platform is designed to act as a learning tank, where anyone can have access to. By not requiring any procedure of providing credentials or personal information we encourage and facilitate the user to visit the platform. The ultimate goal of the Platform is to offer external knowledge to the interested learner, in order to raise awareness on several learning concepts of manufacturing education. Manuskills Platform's structure is based on the underlying logic supporting that the easier the access, the more possibilities for a user/learner to engage with the activities.

Currently the Platform hosts six different experiments that elaborate on various engineering concepts for different age groups of students, as depicted in Figure 3. In more detail, "Ecofactory" experiment addresses the youngest age group of teenagers and provides an introduction to concepts related to sustainability and manufacturing through the use of a serious game, designed specifically for this purpose. Older teenagers are introduced to more specific and complex concepts through "How to build a Skateboard?" and "Interactive Product Assembly" simulations on assembly processes. Finally, young adults, through "Life Cycle Assessment" serious game and "LEGO Exploratorium's" modular activities, can elaborate on LCA procedures and concepts.

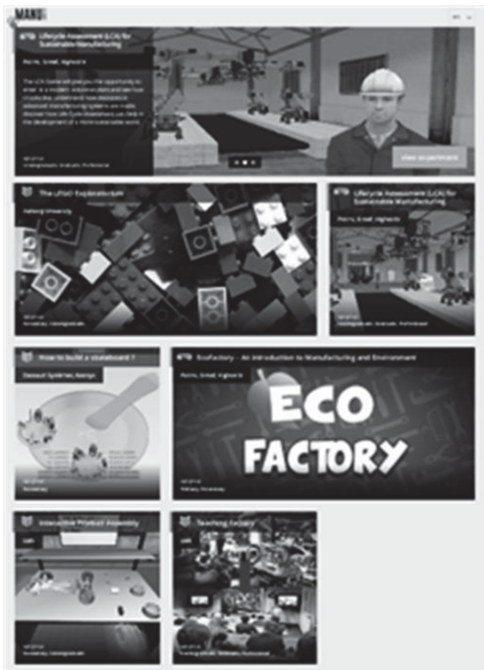

Figure 3: Manuskills' experiments

At this point of the project, the different experiments are tested in real classroom conditions and through the valuable contribution and insights of both participating students and teachers the final outputs will be derived.

Acknowledgements

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Teachers' Many Roles in Game-Based Learning Projects

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Abstract: This paper examines what roles teachers need to take on when attempting to integrate and use computer games in their educational environments. The task of integrating games into an educational setting is a demanding one, and integrating games as a harmonious part of a bigger ecosystem of learning requires teachers to orchestrate a myriad of complex organizational resources. Historically, the field of digital game-based learning research has had a tendency to focus heavily on the coupling between game designs, previously established learning principles, student engagement, and learning outcomes much to the expense of understanding how games impact the working processes of teachers. Given the significant investments of time and resources teachers need to make in order to conduct game-based learning activities, this research gap is problematic. Teachers needs to have a certain amount of gaming literacy in order to actively supervise, support, and guide their students before, during, and after the play sessions. The teacher also needs to be proficient in setting up play sessions in a limited amount of preparation time and tackle eventual technical difficulties. Beyond these demands, teachers also need to serve as a conduit between the learning context and the play context, and need to know how to continuously contextualize game activities and the content that students experience in the subject matter being taught. This paper describes the outcomes of two five month long studies where Swedish K-12 teachers were introduced to using MinecraftEdu as a classroom activity. The study identifies the different roles that a teacher takes on throughout game-based learning processes, such as technical administrator, game administrator, game tutor, subject matter expert, lecturer, debriefer, and classroom supervisor. Ultimately, the paper highlights the importance of understanding the constraints under which teachers work, and argues that a better understanding of the contexts in which games are to be used, and the roles teachers play during game-based learning scenarios, is a necessary foundation for improving games' viability as educational tools.

Keywords: teacher-led gaming, teacher roles, practical implications of classroom gaming

1. Educational games and teachers

As the body of research that points out the potential educational value of games grows, the interest for including more game-based learning in educational processes has increased (Wastiau, Kearney & Van de Berghe, 2009). The discussions on the topic frequently highlight games' intrinsic educational value, such as their experiential nature or their ability to encourage players to master domains through scaffolding and *flow*-evoking designs (Annetta, 2008; Gee, 2009). However, while games' educational values keep being lauded, examples of games being integrated into educational settings are relatively few (Egenfeldt-Nielsen, 2010; Linehan et al, 2011). A past explanation for this disconnect in the game-based learning community has been that the broader community of educators are averse to games. Recent studies, however, have indicated this to be a false assumption as the majority of teachers in the EU and the US are positive towards the idea of using games as educational activities (Ruggiero, 2013; Wastiau, Kearney & Van de Berghe, 2009).

This paper aims to flesh out another explanation for the lack of game integration in the education sector; namely that games are laborious and resource intensive to use, and that there are few standards established to guide educators through the complex process of integrating games into their working environments. There is plenty of research that explores the educational value of games by juxtaposing their perceived qualities with principles of learning (Berg Marklund, 2014; Egenfeldt-Nielsen, 2006). However, examples of empirical work done to understand the practicalities involved in using educational games (Berg Marklund, 2014), such as the tasks teachers need to perform when integrating games into formal educational contexts (Alklind Taylor & Backlund, 2012; Bourgonjon & Hanghøj, 2011; Egenfeldt-Nielsen, 2008), are comparatively rare (Chee, Mehrotra & Ong, 2014).

This paper specifically focuses on examining the roles that teachers need to take on when implementing and using computer games in their classroom activities. The research was conducted during two five month long projects where the researchers collaborated with K-12 teachers to integrate *MinecraftEdu* into their curriculum. The paper does not discuss the educational effectiveness of game-based learning, but rather how classroom gaming affect, and is affected by, the roles teachers need to take on when using games to educate.

2. Method

This research employs case studies to examine the processes teachers need to go through when implementing and using digital educational games in their working environments. The primary methods used during the case studies conducted for this research have been participatory observation protocols, transcriptions of classroom gaming sessions, and interviews with teachers.

The methods were employed during two five-month long instances of educational games use in a Swedish K-12 environment, spanning from November 2014 to March 2015. During the field-work, one researcher collaborated with two different teachers, one teacher working with 7th graders and one working in 5th graders, throughout a game-based learning project. The project entailed initial discussions of educational goals and how games related to them, acquiring game software and implementing it in the classroom environments, and orchestrating gaming sessions. During each of these activities the researcher kept a protocol of observations, and interviews as well as classroom gaming sessions were recorded and transcribed.

2.1 Case study setups

The two different cases constitute two different types of classroom setups. The students in the 7th grade were all part of a national program that supplied them with one laptop per individual, whereas the 5th graders had a limited number of computers to share within their class. The classroom sessions were thus structured differently, as the older students had enough hardware to play games as a whole class (all 24 students could play simultaneously), and the younger students played in smaller groups (dividing 24 students into two groups of 12, that shared six computers). Figure 1 shows the different classroom setups.

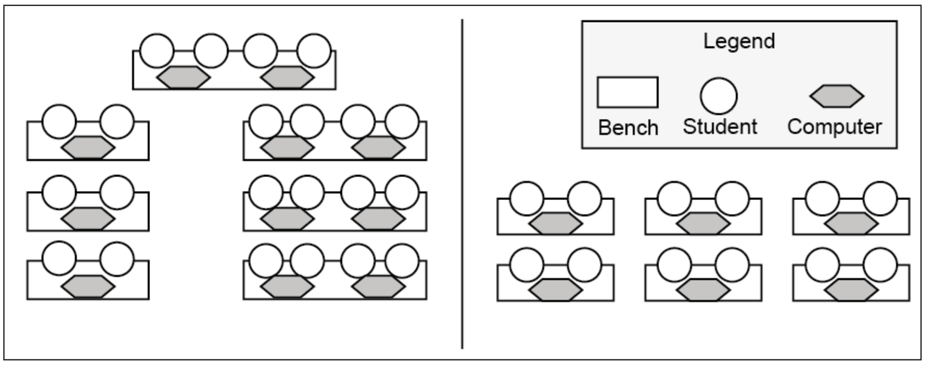

Figure 1: Though the 7th grade students (left) owned one laptop each, they were divided into groups of two and shared one laptop. The 5th grade students (right) worked in groups of two on communal laptops

The two different classes also worked within different subject matters, as the 7th grade class worked with mathematics and geometry, and the 5th grade class worked with medieval history. This informed the structure of the activities the two classes participated in. The purpose of the game-based learning activities with the 7th graders was to let them experiment with length, area, and volumetric scaling in a three-dimensional environment. For the 5th graders, the game-based activities revolved around the research, re-creation, and re-enactment of iconic structures and communities from a specific historical time period (the Middle Ages). As such, the mathematic gaming curriculum focused on heightening students' understanding of geometrical objects and calculations by letting them manipulate and construct those objects first-hand, and the historical curriculum focused on letting students experience and reflect on the taught subject matter through re-creation and re-enactment. Figure 2 shows a snapshot of how these lessons were manifested in the game environment.

The authors would like to emphasise the thoroughly collaborative nature of these game-based learning projects. The field researcher did not passively observe the projects as they unfolded, and played an important part in their execution at several junctures. However, this paper argues that the interventions made by the researcher are interventions that any teacher would need to make in order to integrate games into their classroom environment as well. All interventions were discussed with teachers before they were made, and the interventions served project goals established by the teachers. Since they are likely to be necessary steps in any game-based learning project, the tasks performed by the researcher will thus be analysed as teacher tasks. The outcomes of the studies will be presented below, and examples of the different roles teachers took on during the game-based learning project are coupled with excerpts from transcripts and observation protocols.

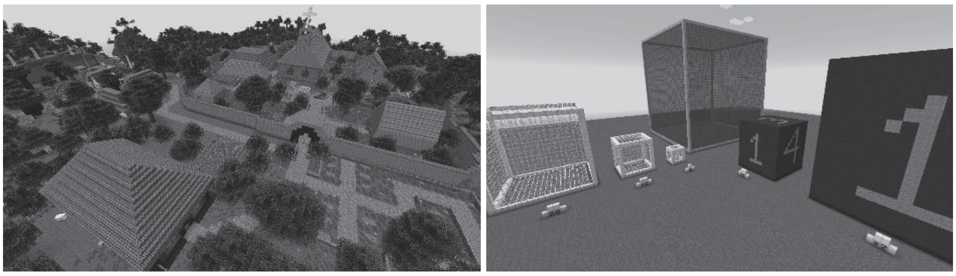

Figure 2: In the history curriculum (left), the students built iconic structures and rudimentary societies from the Medieval Ages (like a monastery and adjoining farms). In the mathematics curriculum (right), the students calculated scale ratios, drew blueprints, and built simple geometric objects and scale models of real-world objects (like the large dice on the right side).

3. Results

In this section, the different roles that the teachers had to manage during two core 'phases' of the game-based learning projects will be presented. The first phase covers the process of integrating the game into the educational setting, and the second phase covers what the process of using the game as a classroom activity entails.

3.1 The conditions of formal education, and their impact on game-based learning processes

An essential step teachers need to take before embarking on any game-based learning project is to assess what they might be able to do given the conditions they are working under. Any formal educational environment consists of elements that can either facilitate or complicate game-based learning processes. In the initial stages of the two case studies, teachers and researchers discussed some of the conditions that were likely to complicate their work, as well as the resources and structures available in their environments that could be valuable assets.

3.1.1 Designing the game-based curriculum

One of the more pressing questions that an educator needs to ask in the initial stages of a game-based learning project is what kinds of gaming sessions their schedule and curriculum allows for. In the studied cases, the curriculum demands and the availability of hardware informed both the choice of game and the plans of how gaming sessions were to be scheduled and conducted. In the class of 7th graders, the abundance of laptops, short period times (45-60 minutes), and the stricter demands and educational goals established in the curriculum made the teacher gravitate towards shorter stand-alone sessions. In the stand-alone session setup, students collaborated in groups of two or played individually on assignments with fixed starting- and end points, which allowed for easier assessments of students' progress. Viewing each classroom session as a stand-alone exercise also had the benefit of allowing for changes in the design of the game assignments according to the rate with which the students mastered both gameplay and details of the taught subject matter. The conditions were quite different in the 5th grade class where the period times were longer (90 minutes), the curriculum goals were less strict, but there was significantly less hardware available. For the younger class, a more long-form collaborative classroom exercise was chosen. Figure 3 shows the basic differences in project structures between the two working processes.

The constraints imposed by curriculum demands and scheduling also play a deciding role when it comes to choosing the type of game to work with. In the studied cases, *MinecraftEdu* was chosen due to its modular nature and accessibility; the game's focus on emergent 'sand-box' play makes it possible for teachers to model gaming challenges after their own educational goals and working conditions (i.e. the game is easily customizable); it runs adequately even on older computers; and it is a title many students are familiar with, thus lowering the barrier to entry for many students. These benefits outweighed the potential drawbacks of the game, such as its low physical, functional, and visual fidelity. For example, it is difficult to create spherical objects in the game (due to its blocky nature), and objects sometimes have little visual resemblance to their real-world counterparts. However, while these types of drawbacks presented some challenges, they were not a major source of concern for the teachers.

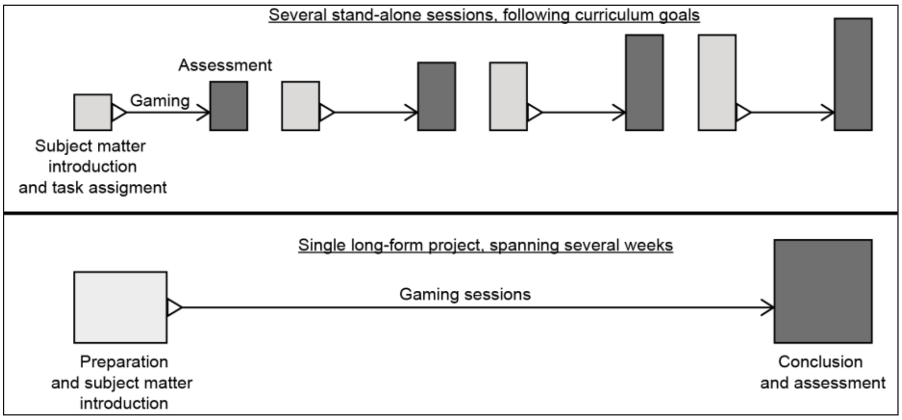

Figure 3: Overviews of the game-based learning projects. The long-form project spanned several weeks of gaming sessions, and more work was done before and after the project to contextualize game content in the subject matter. The stand-alone sessions were more beholden to curriculum demands, and was characterised by smaller assignments, progressively increasing challenge, and continuous assessments

3.1.2 Establishing the infrastructure to enable gaming sessions

When it came to integrating the game into the classrooms, the primary concerns for both cases were: the uncertainty of hardware reliability; the teachers' self-admitted low gaming- and technology literacy; and the limited amount of working hours they could feasibly spend on preparing for classroom gaming sessions. In the cases studied, the low game- and technology literacy of the teachers would make it highly unfeasible to start any type of game-based learning if it were not for a couple of ameliorating circumstances: the presence of the researcher, and the teachers' students themselves as both classes had several students who were very proficient with both computers and the used game. The process of game integration thus relied primarily on the researcher, and when the researcher was not present the teachers could get some assistance from the more technology proficient students in the classes.

Establishing an infrastructure that supports gaming involves taking inventory of the resources currently available in the environment and organization, procuring resources that are currently lacking, and making sure that the needed software and hardware is available and prepared for gaming sessions (these steps are outlined below, in Table 1). The details of this process are likely to differ between schools and classrooms since organizational support structures, technological infrastructures, and teachers' technology literacy is different for each individual case. However, comparing the statements from teachers and observations from this study to previous research indicates that these unfavourable conditions for game-based learning are not uncommon (Egenfeldt-Nielsen, 2008; Linehan et al, 2011; Wastiau, Kearney & Van de Berghe, 2009). Thus, establishing a solid infrastructure that allows for reliable and efficient gaming sessions is likely a task that is not specific to the cases studied here, and it is a task that should not be underestimated as it requires significant investments in resources and effort.

3.1.3 Administrative tasks during and around gaming sessions

An inescapable part of using games for educational purposes is the continuous management of the tools that make gaming sessions possible. Computer games are complex pieces of software that require advanced hardware to function reliably and efficiently. Setting up and orchestrating these components in a classroom environment, even for rudimentary game-based learning activities, constitutes a significant time investment and requires a high level of technological proficiency.

Since the characteristics of the two studied cases differed in many ways, the administrative efforts needed to set up and conduct gaming sessions were different. However, while the specific details of the process differed between the cases, there are definite phases that both needed to go through: taking inventory of their current educational environment and processes, implementing the chosen game into their environment, and conducting maintenance between and during gaming sessions. Each of these phases consisted of several smaller activities.

The necessity of performing the individual activities varied between cases as a result of the classroom setups and the availability of hardware, as shown in Table 1.

Table 1: A summary of the steps involved in the three different phases of integrating and using game technology into an educational environment. Some steps were not applicable to both cases (the X marks whether a step were necessary in the corresponding case)

	Activities	7th grade classroom	5th grade classroom
Inventory	Take inventory of available hardware/resources		X
	Evaluate student profiles		X
	Examine curriculum goals	X	X
	Examine game software	X	X
	Establish educational goals to be served by the GBL project	X	X
	Pull in organizational support structures	X	X
Implementation	Prepare hardware		X
	Purchase game licenses	X	X
	Installation of software	X	X
	Prepare the classroom environment		X
	Prepare the game environments		X
Maintenance	Maintenance	X	X
	Setting up servers		X
	Preparing in-game examples	X	
	Saving games and handling backups		X
	Tech-support during game sessions	X	X
	Closing down lessons		X
	Hardware maintenance		X
	Patching and software maintenance	X	X

To provide a few concrete examples of how steps differed between the two cases, the stand-alone exercise design chosen by the 7th grade teacher alleviated the need to prepare the game environments students played in. As the students in those classes also worked on their own computers, the classroom and hardware did not need any notable preparation before game exercises, nor was setting up servers or saving and keeping backups of game data necessary. However, due to the higher amount of computers, the process of installing the game software was longer, more intricate, and more prone to errors. As the stand-alone sessions followed a steady progression of challenges, the classes required preparations of in-game examples of different mathematical expressions in *Minecraft*. That was not necessary in the 5th grade class, since they worked on a long-form creative exercise where students mainly followed their own building plans.

3.2 Conducting classroom sessions

Once the conditions necessary for game-based classroom activities are met, the teachers can start becoming more focused on conducting said activities. Classroom gaming requires the teacher to be versatile as they need to carry out the necessary preparations before gaming sessions, but also act as game administrators during them. During exercises, the teacher also needs to tutor students both in the taught subject matter and in the gameplay of the chosen game, and will also need to step into an authoritative role whenever necessary to keep students focused.

3.2.1 The teacher as gaming tutor

Beyond the practicalities of ensuring that game sessions run reliably from an administrative perspective, the teacher also needs to be able to guide and support students' gaming experiences during gaming activities. Being a game tutor for students entails several responsibilities for the teacher, and given the variation in individual students' proficiencies and interests this task can be rather difficult.

The heterogeneity of a K-12 classroom as a gaming audience cannot be understated. Each individual student has their own levels of gaming literacy, gaming preferences, subject matter knowledge, motor skills, motivations to play and learn, socio-economical background, and general interests. In both of the studied cases, a large portion of the teachers' and researcher's classroom interventions consisted of helping students launch the game, and subsequently to understand the basic interface and concepts of *Minecraft*. As an example, in an observation protocol from a gaming session with the 7^{th} grade class on the 22^{nd} of January, the researcher described their role the following way: "*A lot of students (around a fourth of the class) still don't know how to start the game or how to play, how to interpret 'blocks' as units of measurement, how to choose and place blocks in the game interface, or even how to steer their avatar (the combination of WASD steering and mouse movement is difficult for many), I spend a lot of time running around and managing those issues*."

In this example, some students had problems launching their game and navigating a game interface that some might consider self-evident. Building on this, the collection of transcript excerpts below show how severely students' grasp and approach to the game can vary in a single class during the same gaming session (translated from Swedish, all students are given pseudonyms):

Excerpts from a transcript of a 7^{th} grade classroom gaming session, February 27^{th}

Jonas:	Minecraft on highest settings - I'm running that on my computer at home. Desktop rig. No lag. Here you get lag at the lowest settings...
Sif:	[To researcher] You have to help me, I don't know where I need to go [to start the game]... is it this one?
Pete:	[To classmate] What program are you using? WorldLevel?
Wallace:	It's spelled "WorldEdit". But you have to know... you have to write it into google.
Wallace:	You can check out tutorials on YouTube of how to install it.
Pete:	Alright, WorldEdit. Here it is.
Rose:	I'm getting pretty good at this.
Rose:	Wait, I forgot how to do this...
	[...]
Rose:	This is the second time I'm playing Minecraft!

The heterogeneity of K-12 students can make classroom sessions difficult to design and monitor as the students who have never played a computer game before needs to be able to collaborate and communicate with students who are very proficient players. As the excerpt shows, students' proficiency in using technology and playing games can differ severely in a classroom. While some students are struggling with the basic interface, others are advanced enough to complain about hardware performance, or will start to modify the game in order to elevate their gameplay further since the basic game is not engaging enough.

3.2.2 The teacher as authority and enforcer of educational modes of play

Novice students' are not the only ones that require guidance, as more proficient players also frequently need to be guided towards productive collaborations with their classmates. In previous studies, Frank (2012) has shown that proficient players can become overly focused on self-actualization through mastery of game mechanics or achievement of game goals, to the exclusion of engaging with the subject matter that the game is intended to represent. A constructive and focused student-to-student discourse is reliant on the gaming activity remaining 'framed' as an educational activity that students partake in by playing with a reflexive and analytical mind-set. During both studied cases, student groups frequently became unfocused when the act of gameplay separated itself from the educational goals of the classroom sessions. After a classroom activity on the 20^{th} of March, the 7^{th} grade teacher reported that: "*Sometimes the game is more enticing than working and focusing on the assignment. For example, a friend might look for facts about the [subject matter topic], so meanwhile [the other student] can play around freely in the Minecraft world*." These behaviours emerged quite frequently in the transcripts as well:

Excerpt from 7^{th} grade classroom transcript, February 27^{th}

[Anna and James are meant to be building a scale replica of a real-world object inside of Minecraft, the exercise has been going on for nine minutes, James has been spending most of the time using TNT to blow up things in their Minecraft world, while Anna has been trying to get him to work on the assignment]

James:	I'm going to do an awesome thing.
Silence, lots of mouse clicks	
Anna:	Teacher! Can we get some help?
Pause, the teacher comes over	
Anna:	What do you mean by "Settle on a scale"?
Teacher:	Have you decided how to scale the object you're building?
Anna:	Yes.
Teacher:	Have you decided how 'large' your blocks are [in Minecraft]?
Anna:	No.
[...]	
Teacher:	You need to decide the measurements of your blocks.
James:	Oh, how large they're going to be?

[From this point, James joins in on the discussion of the assignment]

In situations such as these, the teacher's presence seemed to help reinforce the educational framing of the gaming activity. There are several other examples in the transcripts of the teacher being called upon to mediate these situations. In many of the examples, the teacher is utilized by some students as a 'technique' to get their more game-focused working partners to focus on the class assignment. These situations most frequently occurred in groupings where students with clear "gamer" personalities were matched with less game-proficient students.

3.2.3 The teacher as subject matter anchor

One commonly recurring challenge the teacher tackled during gaming sessions was to bridge the gap between the game content and the details of the subject matter the game is intended to teach. By necessity, games often make compromises in physical-, task-, and functional fidelity (Liu, Macchiarella & Vincenzi, 2009). Games rely a lot on abstractions and representations, and players continuously 'translate' game actions to real-world actions – if the game action is very dissimilar to the real-world action, there is always a risk that things get lost in translation. If a game is not specifically designed to teach the details of the subject matter with a high level of authenticity and fidelity, the task falls on the teacher to draw connections between the game content and the subject matter (Alklind Taylor & Backlund, 2012).

In situations where there is a disconnect between the game's presentation of an action or object and its real-world counterpart, the teacher needs to step in and provide context to fill the gap. Due to the low-fidelity nature of *Minecraft*, both in terms of visuals and object functions, disconnects can occur rather frequently. The modes of interaction presented by the game are very rudimentary, and the objects the players interact with are also visually and functionally minimalistic. When working with complex themes and concepts (e.g. history, social sciences, ecology, biology, etc.) in such minimalist environments, students need to collectively 'pretend' that certain objects should be interpreted and used a certain way. For example, the students in the 5th grade class used "Spider Webs" as puffs of smoke due to their visual similarity to tiny white clouds, even though the mechanics of the object share no similarities to smoke. Conversely, students sometimes disregarded an object's visuals if the functionality it represented was in line with what they aimed to convey. For example, students relied on the "Chest" object as a universal symbol for 'storage', and used it as such even when its visuals clashed with the setting. Some students are very adept at negotiating what qualities of objects they should 'see' and which ones they should disregard, but just as is the case with gaming proficiency – this skill varies radically between individual students. The below transcript excerpt contains a situation in which students have trouble seeing past small disconnects between game content and the subject matter:

Excerpt from 5th grade classroom transcript, February 3rd - clashes between game visuals and subject matter

[Julie and Louise, two inexperienced players, are building part of a monastery, they want a bookshelf in their building (it's a building where they would be thematically appropriate), so they place one down, a brief silence follows, and the following exchange takes place]

Louise: A little bit too colourful, right?

[…]

Julie: Let's remove them.

Louise: Yeah.

They go quiet, mouse clicks are heard, the teacher comes up to the group

Teacher: Why did you remove them?

Louise: It looked a bit weird.

Julie: Yes.

Teacher: A little bit too modern?

Julie and Louise: Yeah.

Teacher: Well, there are modern-looking book spines in there, but you can try to imagine that they're the type of books they would have back then.

In this example, the visual representation of bookshelves in the game (being slightly modern) clashes with the subject matter (medieval history). This can be viewed as an example of limited physical fidelity being troublesome to negotiate and challenging the collective act of 'pretending'. However, disconnects can also occur when students encounter situations where the game's functional fidelity is low:

Excerpt from 5th grade classroom transcript, February 3rd - drawing on subject matter details to guide gameplay

[Julie and Louise are debating what type of door to have on their building]
Julie: Now I'll attach a door.
[…]
Julie: Wooden door or Steel door?
Louise: Eeeeh…
Julie: What kinds of doors did they have?
Pause
Louise: Yeah, what door is most fitting?
Julie: [Asks the researcher] Should we have a wooden door or an iron door?
Researcher: I feel like wood was much more common. It's really difficult to create things out of metal, especially so during those days.
Louise: Yeah.
Julie: Let's go with the wooden one.

The teacher's task in these situations is to maintain the established 'contract' that state that the fiction of the subject matter is to be maintained, even when the game itself does not enforce it in any way or even tempts students to break it. For example, steel doors are no more difficult to access or place in *Minecraft* than wooden ones, making them functionally similar, but by discussing the subject matter the students start imposing constraints in service of subject matter adherence.

4. Conclusion and discussion

By collaborating with teachers during a game-based learning project, this research could reveal several important roles that teachers need to take on when integrating and using games in their educational environment. The skillsets needed to perform the roles well were also found to be quite diverse as they involved technological know-how, gaming literacy, subject matter expertise, and naturally a strong pedagogical foundation.

At the outset of a game-based learning project, the teacher needs to be able to review the conditions of their educational environment. Organizational support structures, availability of hardware and software, and the availability of other resources or obstacles, need to be considered before the game-based learning curriculum is designed. Basic practicalities like class schedules, educational goals as stated by national curricula, and technological infrastructure all inform what type of game can (or should) be used, as well as the design of gaming sessions and assignments. These findings, in contrast to the ones made by Chee, Mehrotra and Ong (2014) whom suggests that "*the key challenges teachers face are not technology centric but practice centric*" (p. 313), identify technology availability and literacy as a major bottleneck and guiding factor in the integration of digital game-based learning in schools.

When actually conducting the classroom gaming sessions, the teachers need to take on another set of roles. During a typical gaming session, teachers need to act as game administrators, lecturers, game tutors, subject matter anchors, and authority figures that keep students in an educational mode of play. In a big classroom, it can be difficult for teachers with low gaming literacy to spot situations where novice students are struggling with the game interface, or when students are not working towards educational goals. However, being game literate does not necessarily entail game mastery, but rather that the teacher can understand gaming and game content in order to make use of it. As put by Bourgonjon and Hanghøj (2011), "*teachers don't necessarily need to become experts with every new medium, but at the very least need to know what is going on […] in order to participate*" (p. 71).

Gaming literacy is not only important for gaming sessions, but also for the teacher to be able to plan and conduct contextualising activities 'around' their gaming sessions. For example, the 5th grade teacher introduced the students to the medieval history concepts they were going to be working on in *Minecraft* long before the gaming sessions started. After the gaming project was over, the teacher also pulled aspects of the buildings and societies the students had created into other school-work. Although these surrounding exercises were not highlighted in this research, they played an important role in exploring more intricate details of the subject matters. Constructive learning situations arose occasionally during gameplay as well, but the surrounding exercises provided the necessary contextual knowledge that allowed such situations to occur. The gameplay itself did not have much intrinsic educational value, but when it was contextualized appropriately and executed purposefully, it played an interesting and valuable part of larger learning processes.

This paper has shown that game-based learning processes are demanding on teachers, requiring them to take on many different roles, each of which requires a specific skillset. Integrating games into formal educational settings is a laborious and complex process. This is partly due to the fact that schools are not structured for game-based learning, making the process an up-hill struggle, but it is also due to games not being sufficiently accommodating for the needs of teachers or the many characteristics an educational context may have. For game-based learning to move forward, teachers need to have a better understanding of games and how to work with them, and game creators need to understand teachers' working conditions and know how to accommodate for the varying characteristics of formal educational settings with their products.

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Assessing an Authoring Tool for Meta-Design of Serious Games

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Abstract: In order to help teachers to adopt serious games, we explore the problem of applying the meta-design principles to this context. The goal of meta-design is to enable end-users to act as designers as well as at design stage than at use time. We focused our work on helping teachers adapt educational aspects of serious game scenarios to their pedagogical needs. Our research leads us to design an authoring tool named APPLiq based on a generic model for serious games scenarios named MoPPLiq. In this paper, we first describe the three main aspects of the model MoPPLiq. First, we introduce the concept of meta design. Second, we introduce MoPPLiq and how it models scenarios by sequences of discrete black boxes named “activities”. Then, we describe the “output states” that allow model the critical choices of the serious-players that can modify the course of the scenario. At last, we describe “input states” that aim to model the dynamic adaptation to serious-players, i.e. when an activity changes its behavior depending on the serious-player's model. After detailing MoPPLiq, we introduce APPLiq and its main features. APPliq is meant to design and adapt educational and recreational serious game scenarios. Therefore, we describe the main features of APPLiq: On one hand it depicts with a graphical representation the scenarios modeled with MoPPLiq. On the other hand, it provides a graphical user interface to change connection between output and input states of activities. APPLiq also provides a checking system that is able to check a serious game scenario for inconsistencies in the pedagogical scenario or in the game design. This system is also able to compensate automatically the non-pedagogical inconsistencies thanks to “buffer activities”. Finally, we describe the protocol and the results of a qualitative assessment that we conducted with about 20 teachers for several weeks on APPLiq and MoPPLiq. The discussion of the results shows that the graphical representation of MoPPLiq helps teachers to understand the ins and outs of the serious game they had to use during the experimentation. On the other hand, despite some ergonomics problems on the prototype of APPLiq tested, the results show that the authoring tool allowed teachers to create and to modify serious game scenarios that they declare relevant for their use.

Keywords: serious games, meta-design, authoring tools, scenario, game-design

1. Introduction

The educational prospects of serious games (SGs) for learning are interesting, yet their adoption remains scarce (Azadegan et al., 2012).

MoPPLiq and *APPLiq* are two contributions to the problem of meta-design for SGs. A fundamental objective of meta-design is to create a socio-technical environment allowing users to assume the role of co-designers by adapting systems (Fischer et al., 2004). To facilitate adoption of SGs, the meta-design approach aims to foster instrumental genesis by teachers (Rabardel, 2003).

MoPPLiq is a model describing educational (i.e. pedagogical) and recreational aspects of scenarios of the SGs that break down into distinct levels. This model aims to facilitate instrumentation of SGs by teachers. In a model-driven engineering approach, APPLiq implements MoPPLiq. APPLiq is an authoring tool meant to adapt SGs in order to help teachers instrumentalize SGs without damaging their recreational consistency (Marne & Labat, 2014b).

We conducted a qualitative experiment for several weeks with teachers in order to inform the design of these two tools. We had two objectives. On the one hand, we tested if APPLiq and MoPPLiq enabled teachers to adapt the educational scenario of an SG, and if they were considering the adapted scenarios ready to be used with students. On the other hand, we tested if MoPPLiq and APPLiq helped the teachers to master the SG itself.

In the first section of this paper we introduce the meta-design for SGs. Then, in the second section we briefly introduce MoPPLiq and APPLiq. Then, in the third section we present the SG used for our qualitative experimentation. In the fourth section we define the indicators that we monitored to assess MoPPLiq and APPLiq. In the fifth section, we detail the protocol and the recruitment of teachers for the experimentation. Finally, in the last part, we present and discuss the results before concluding.

2. Serious games, authoring and meta-design

SG design involves several classes of experts. On the one hand there is knowledge engineers, teachers, educators, domain experts and so on (that we broadly group as pedagogical experts), and on the other hand there is game and level-designers, game producers, sound and graphic designers and so on (broadly grouped as game experts). Various authors point out that multi-expertise design is one of the main challenges of SG design (Marfisi-Schottman, 2012; Mariais et al., 2012; Marne et al., 2012; Kelle et al., 2011; Marne, 2014). This can be addressed with several approaches detailed in previous research work. There are merely two different classes of approaches: participatory design and meta-design.

Participatory Design (PD) approaches intend to place the end-users as full participants of the design (Muller, 2003). For SGs, there are two classes of users. On the one hand the real end-users are the "serious-players". On the other hand, the teachers (or trainers and tutors), who are the prescribers, are not really the end-users, but still are users of SGs, because they use them for teaching. We choose to focus our research on teachers-users, mainly because we wish to help them introduce more SGs in their courses. Accordingly, PD approaches tackle the issue of multi-expert design by helping several classes of designers (i.e. pedagogical and game experts) to work with users.

However, PD only addresses the design stage. (Rabardel, 2003) showed that the appropriation of artifacts so called "instrumental genesis" is also involving the end-users as designers far beyond the initial design stage: "instrumentalization" when end-users are adapting the artifact to their needs, and "instrumentation" when end-users are learning the workings ("schemes") of the artifact. Meta-design is another approach than PD, which reconciles the latter with instrumental genesis and with the use stage. Indeed, Meta-design covers all the methods that allow end-users (so called "owners of the problems") to act as designers both at the design stage and throughout the use stage (Fischer et al., 2004). This approach leads our research in order to help the teachers to introduce more SGs in their teaching. Meta-design implies the development of frameworks and models to be used as boundary objects, and authoring tools to operationalize them in order to allow end-users to act as authors. MoPPLiq and APPLiq are examples of a model and an authoring tool meant to enable teachers to act as designers during the use stage by instrumenting and instrumentalizing SGs.

In the following section, we introduce a model and an authoring tool meant to help teachers to meta-design SGs and that we tested with some of them.

3. The MoPPLiq model and the authoring tool APPLiq

The MoPPLiq model is meant to describe educational and recreational aspects of discrete scenarios of SGs (Marne & Labat, 2014a). This model is based on three main features derived from other research on interactive tutoring systems, video-games and SGs. The three features are:

- Scenarios are broken down into components named "activities" (e.g. levels, exercises, case studies). Activities are black boxes that are only defined with goals for the serious-players (Dalziel, 2008; Koper & Olivier, 2004).
- For each activity, the serious-players' possible choices that have an impact on the whole scenario are described with output states. Those output states allow building branched scenarios (Marfisi-Schottman, 2012).
- If an activity has several behaviors depending on the serious-players' profile or previous actions, these behaviors are described with input states. Thus, input states allow the description of the dynamic adaptation of activities to serious-players (Brusilovsky, 1996).

Figure 1: The three main features of MoPPLiq: activities, input and output states

Input and output states are characterized by educational and recreational goals for the serious-players. Input states are indexed with “prerequisited” goals, output states are indexed by “worked on” goals. Each output state can be connected once to input states in order to build a scenario. Figure 2 depicts the graphical representation of the MoPPLiq model of the SG “Les Cristaux d’Éhère” (described in the next section).

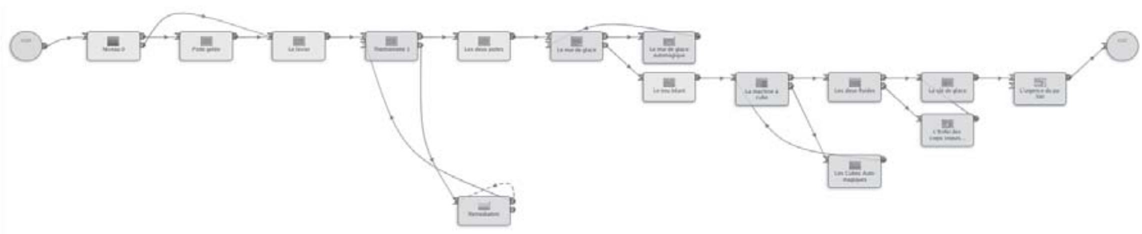

Figure 2: Shape of the scenario of "Les Cristaux d'Éhère" modelled with MoPPLiq

MoPPLiq is also a formal model expressed in XML, which allows us to embed it into an authoring tool meant to enable teachers to adapt SG scenarios. The Authoring tool, named APPLiq, provides a graphical user interface (GUI) to (1) display scenarios of SGs (e.g. Figure 2 is a part of APPLiq GUI), (2) enable users to create and modify connections between input and output states, (3) automatically verify the consistency of the scenarios, (4) provide a semi-automatic consistency correction for storyline issues. The consistency is checked with a set-theoretic operation that verifies that the set of "prerequisited" goals is necessarily included in the intersection of the sets of possible "worked on" goals. If a teacher builds or adapts a scenario and an inconsistency is detected on educational goals, APPLiq raises an alert, and lets the user decide whether or not to correct it (a scenario that seems inconsistent inside the SG may be consistent when orchestrated by its author with its students). However, if the inconsistency is on recreational goals, APPLiq will provide a set of "buffer activities" meant to add the missing goals to the scenario.

4. An SG prototype for testing: Les Cristaux d’Éhère

In order to make a qualitative testing of MoPPLiq and APPLiq we designed a prototype of SG named “Les Cristaux d’Éhère”. This SG is a static puzzle game (Karhulahti, 2013) meant to teach matter phases and their change to French middle school pupils[1]. Figure 3 shows a screenshot of the SG. In the game, the serious-players play an avatar and have to solve matter phase based puzzles in order to exit a dungeon broken down into several rooms (i.e. levels of the SG). Each room (level) has its own pedagogical and recreational goals.

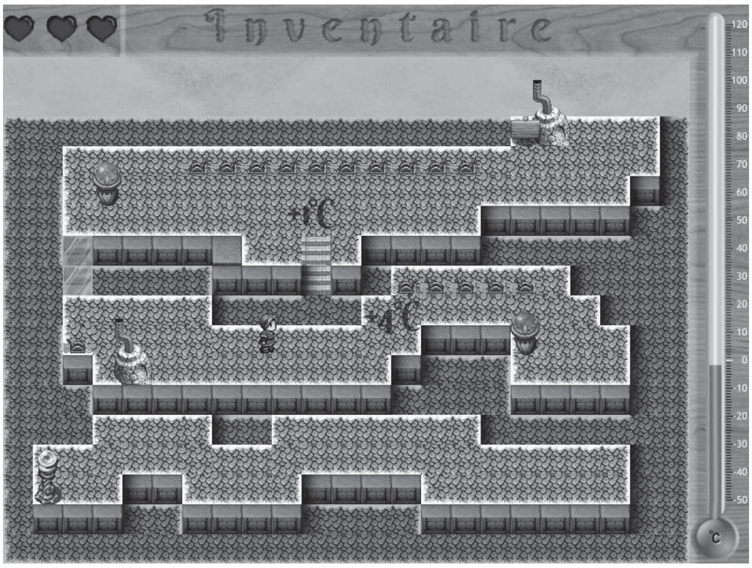

Figure 3: screenshot of a level of the SG prototype “Les Cristaux d’Éhère”

5. Assumptions tested and indicators used to experiment on them

To test and to improve MoPPLiq and APPLiq we made an experiment involving real users: teachers. We had two main assumptions to test with this qualitative experiment:

[1] The prototype is available online: http://seriousgames.lip6.fr/Cristaux_Ehere/

- Assumption #1: the graphical representation of the MoPPLiq model provided by APPLiq helps teachers to understand the ins and outs of the SG scenario
- Assumption #2: APPLiq enables teachers to design and modify SG scenarios in order to obtain new scenarios that they consider suitable for their classroom.

In order to test each assumption, we defined several indicators described in the following sub-sections.

5.1 Indicators for the assumption #1

We compared the teachers' understanding of an SG scenario in two different situations: before having seen the MoPPLiq model and after. For this purpose, we decided in a first step to let the teachers play Les Cristaux d'Éhère and then describe some specific aspects of the scenario after they had finished the game. The questions aimed to test if they have played all the levels and if they had a wide understanding of the scenario. In a second step, we gave the graphical representation of the scenarios to the same teachers, and then we asked similar questions. We also asked them to discuss how the graphical representation helped them understand some aspects of the SG.

5.2 Indicators for the assumption #2

Our first indicator to test the second assumption is to assess the consistency of the scenarios designed and modified with APPLiq by the teachers. Our second indicator is to ask the teachers to assess their own scenarios and to tell us if they are willing to use them with their students. For this purpose, we gave them the opportunity to create new scenarios with a specific pedagogical purpose and to adapt a suboptimal scenario to some pedagogical constraints. In the next section we detail how we managed that with the experimental protocol.

6. Protocol, recruitment and conduct of the experiment

The major issue for this experiment was to recruit some teachers that had a wide knowledge of the targeted curriculum and had enough time to discover the SG, test APPLiq in various situations and report the results to us. This led us to choose to design a remote experiment (online) broken down into six steps detailed below.

6.1 Experiment protocol

The protocol is broken down into 6 steps.

Step #1. Introduction: On the one hand, the experiment is presented to the participants. On the other hand, the participants have to fill out a questionnaire about themselves.
Step #2. Quick start and assessment of the SG: The participants have to play Les Cristaux d'Éhère and consider how they might use it with their students. Afterwards, we submitted a survey about their assessment and understanding of the SG (assumption #1).
Step #3. Discovering the graphical representation of the scenario: The participants are allowed to study the MoPPLiq graphical model of the SG. They are asked to search for the activities that are meant to teach some specific competencies. Afterwards, they have to fill up another questionnaire meant to test their understanding of the scenario and to survey their thoughts about the graphical representation of MoPPLiq (assumption #1).
Step 4 and 5. Creating a new scenario and adapting another one: The participants are allowed full access to APPLiq and its documentation. At the step #4 they are asked to create a new scenario meant to teach a specific content. At the step #5 they are asked to modify a suboptimal scenario to meet some specific pedagogical needs. Eventually, at the end of each step, they are surveyed on whether or not their scenarios are suitable for their students. (assumption #2)
Step #6. Ending: A last survey is made to collect information on the second assumption.

All the experiment was done remotely through the internet. Accordingly, we developed a website to provide a dashboard to the participants in order to read the instructions, gather information, fill up and submit the forms, play the SG and use APPLiq. At the end of each step, the form submission unlocks the next step.

We are aware that having a remote experiment is a bias: the participants had to fill up static questionnaires, which is far from an interview that allows to ask some adapted questions, especially to avoid some evasive or incomplete answers. Besides that, several of our indicators rely on their claims. Even if we tried to ask proper questions to minimise wrong declarations, we think that we have to be careful with the results. Nevertheless, in order to experiment MoPPLiq and APPLiq on numerous real users, we had no other choice but to conduct our experiment remotely.

6.2 Recruitment

To recruit suitable participants for our experiment we used the mailing lists of the teachers of physics and chemistry from middle school (target of the SG). Therefore, all participants were voluntary and unpaid. This may also be a bias because the teachers willing to test an SG are not representative.

6.3 Conduct of the experiment

36 teachers contacted us to participate, and only 31 really started the experiment. Yet, only 27 submitted the first questionnaire at the end of the step #1.

During the experiment, all remaining participants were followed on a daily basis. This means that sometimes they were helped when they needed, they were reminded to go further when they were idle for a long time. Given that processing the 6 steps in a row took us about 4 hours, but that all participants had a very busy life, we gave them four weeks to finish all the steps. Unfortunately, despite the inducements and comforting messages there have been several dropouts. Table 1 shows the evolution of participant number during the experiment.

Table 1: Number of participants stuck at each step

Steps	Step #1	Step #2	Step #3	Step #4	Step #5	Step #6
Remaining participants for each step	4	7	2	6 (3 did not create any scenario)	3 (2 did not adapt any scenario)	9

Despite an encouraging number of participants, we were able to test our first assumption with only 18 teachers, and our second assumption with only 9 teachers.

7. Results and discussion

The results we present in this section are a sub-part of the whole results of the experiment conducted and are discussed from the point of a qualitative analysis meant to help us improve the design of both MoPPLiq and APPLiq.

7.1 Results for assumption #1

The results showed in Table 2 are made from two sets of questions asked to the participant at the end of the step #2 (playing the SG) and the step #3 (exploring the MoPPLiq model).

Table 2: Comparison of the understanding of the scenario after steps #1 and #2

7B7Baliases	**8B8B**Step #2 : Reminding the scenario after playing it (on 2)	**9B9B**Step # 3 : Reminding the scenario after studying the model (on 2)	**10B10B**Differences between steps #3 and #2	**11B11B**Claims that the model helped to understand (on 4)
B	1	0	-1	2
E	1	2	1	4
G	1	1	0	3
J	1	1	0	3
K	1	2	1	4
L	2	2	0	4
M	1	2	1	4
N	1	1	0	1
O	2	1	-1	4
P	0	1	1	1
Q	1	2	1	4
R	1	1	0	4
S	0	1	1	3

7B7Baliases	**8B8B**Step #2 : Reminding the scenario after playing it (on 2)	**9B9B**Step # 3 : Reminding the scenario after studying the model (on 2)	**10B10B**Differences between steps #3 and #2	**11B11B**Claims that the model helped to understand (on 4)
T	1	2	1	4
V	1	2	1	3
X	2	2	0	3
Y	2	2	0	3
Z	1	1	0	2

Our analysis shows that the participants better remembered the scenario after studying the MoPPLiq model (step #3) than after playing it thoroughly (step #2). Only 4 out of the 18 participants of both step #2 and #3 claimed that they had a good understanding of the SG at the end of the second step. Whereas 9 out of the 18 claimed at then end of the step #3 to have a good understanding of the scenario. Moreover, the table shows that 8 out of the 18 had a better understanding of the SG after the third step than after the second one. Accordingly, 14 of them claim that studying the MoPPLiq model helped them to remember and understand the scenario. It also means that it is not the case for four of them.

The participants were allowed to justify their choices with responses (Figure 4). In a nutshell they said that the graphical representation and the input and output states of MoPPLiq helped them understand the scenario of Les Cristaux d'Éhère.

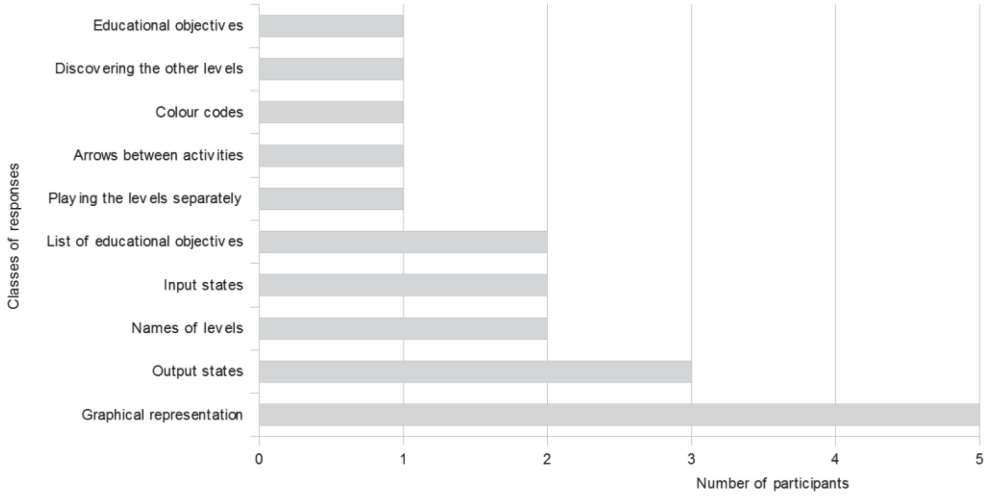

Figure 4: Responses of participants regarding their understanding of the SG scenario viewed in APPLiq. Responses are grouped into classes

Regarding the first assumption, the teachers' testimonials show that graphical representations of input, output states and their links especially helped them understand the scenario. Their detailed responses also lead us to conclude that they had a better understanding of the scenario after viewing it rather than after playing it. These results may seem obvious, nevertheless they increase our belief that our first assumption is true, i.e. the graphical representation of MoPPLiq provided by APPLiq helps the teachers grasp the scenario of an SG.

7.2 Results for assumption #2

In order to test the second assumption we assessed the scenarios designed by the teachers by seeking the presence of 7 features: (1) the scenario must embed activities dealing with solid water (ice) , (2) there isn't any inconsistency in the storyline, (3) there is no significant educational inconsistency, (4) the scenario has branches, (5) the scenario has buffer activities, (6) the scenario has more than 3 activities (buffer activities excepted), (7) the scenarios has at least one activity (buffer activities excepted). We decided to quantify the features by summing their presence (last column of Table 3)

Table 3: Assessment of newly designed scenarios

Aliases	1	2	3	4	5	6	7	Sum (on 7)
B		yes	yes		Yes			3
E	yes	yes	yes		Yes	yes	yes	6
K	yes	yes	yes		Yes		yes	5
M	yes	yes	yes		Yes			4
O	yes	yes	yes	Yes	yes	yes	yes	7
Q	yes	yes	yes	Yes	yes	yes	yes	7
V	yes	yes		Yes	yes		yes	5
X		yes	yes		yes			3
Y	yes	yes		Yes	yes		yes	5

Teachers also had to modify an already existing suboptimal scenario. We assessed these modified scenarios by seeking the presence of 7 features: (1) the sequence of activities has been changed, (2) there isn't any inconsistency in the storyline, (3) there isn't anymore educational inconsistency, (4) every activity of the scenario is connected. Features are summed in the last column in Table 4.

Table 4: Assessment of modified suboptimal scenarios

Aliases	1	2	3	4	Sum (on 4)
E	Yes	Yes		yes	3
K	yes	Yes		yes	3
M	yes	Yes			2
O	yes	Yes			2
Q	yes	Yes	yes	yes	4
R	yes	Yes	yes		3
Y	yes	Yes		yes	3

Analyzing both tables, on the one hand the newly designed scenarios (

Table **3**), and on the other hand the modified scenarios (Table 4), shows that they both have not any inconsistencies in the storyline. This seems to enforce our confidence in the automatic inconsistency compensation system provided by APPLiq. Moreover, we regard the scenarios with high scores as suitable for being used with students. Therefore, 7 out of the 9 newly designed scenarios are suitable for being used with students. 5 out of the 7 modified scenarios are also suitable for being used. These elements increase our belief that the second assumption is true.

The analysis also shows that the number of participants that choose to design branched scenarios is small (4 participants out of the 9), and that they all tended to build very short scenarios (between one to three activities).

The questions asked at the end of the steps #4, #5 and # 6 provide more insights (Table **5**). The questions refer to whether or not the participants were satisfied with their scenarios (end of steps #4 and #5), and if they think that they are ready to be used with students. Table **5** also includes the sums presented in the last columns of Table 3 and Table 4

The analysis of the result shows that 6 out of the 9 participants are quite satisfied with their newly created scenarios (step #4). Paradoxically, the 3 participants (M, O and Q) that claim to be the most unsatisfied of their newly created scenario, are the one that have made the best scenarios (

Table **3**), and they claim that their scenarios are usable with students. The responses (Figure 5) they gave do not help us to solve the paradox. The analysis of the results also shows that the 6 participants also regard their scenarios as usable with students. This is very close to our own measurement (Table 3)

We have made similar findings with the modified suboptimal scenarios (step #5). Most of the participants (4 out of 7) are satisfied. Here again, the unsatisfied participants (E, Q and Y) are the one with the best scenarios (Table 4), and they also consider them as usable with students. Therefore, the participants that design good scenarios struggle to convince themselves of the quality of their work (even if they also consider the work usable with students). The results equally show that for newly designed scenarios and for suboptimal scenarios.

Table 5: Claims of the participants about usability of their own scenarios

Aliases	Step #4 : newly designed scenarios			Step #5 modified scenarios		
		Claims			Claims	
	Previous sum (on 7)	Satisfied with the scenario (on 4)	Usable? (on 6)	Previous sum (on 4)	Satisfied with the scenario (on 4)	Usable? (on 6)
B	3	4	1	0	4	1
E	6	4	1	3	1	6
K	5	3	6	3	4	2
M	4	2	4	2	3	3
O	7	2	5	2	3	2
Q	7	2	5	4	2	5
R	0	4	1	3	4	1
V	5	3	1			
X	3	3	6	0	4	6
Y	5	3	4	3	2	4

Furthermore, the participants seem harsher with their modified scenario than with their newly created one. Indeed, only 4 out of the 9 participants claim their modified scenario as usable with students. This is also harsher than our assessment (Table 4).

Figure 5 is based on the responses provided by the participants.

Figure 5: Responses made by the participants about the scenarios they provided. Responses are grouped into classes

The two most popular responses are about the difficulty managing inconsistencies (mainly educational ones). Moreover, the participants frequently claimed to lack of time in order to provide decent scenarios. These responses are also clustered by themes in Table 6.

Table 6: Themes of the responses made by participants regarding their scenarios

Themes	Classes of responses
Usability of APPLiq	Inconsistencies are difficult to manage Suppressing an activity or changing their order is difficult It is not convenient to plug activities I didn't manage to use APPLiq It would be easier to work with several tabs (windows) Inconsistencies are clearly labeled Drag and drop GUI may be more convenient
MoPPLiq model and methodology	The building process for a scenario is understandable The input and output state principles are understood

Themes	Classes of responses
	The students are able to overcome some inconsistencies
APPLiq features	The building process for a scenario is interesting A timeline of the objectives may be convenient There is bugs in APPLiq
Les Cristaux d'Éhère (SG)	Some activities regarding specific objectives are missing Importing a scenario into the SG failed
Scenarios produced	I'd rather not add more activities My scenario is too short
External elements	I ran out of time

The analysis of the responses themes shows that most comments (7 occurrences, including only one positive) are related to ergonomics. As the version of APPLiq tested was a prototype this seems very appropriate. Many responses are related to the model and the scenario design methodology (3 occurrences, including only one negative) and to the features of APPLiq (3 occurrences, including only one positive). In these responses the participants give us some ideas to improve APPLiq's features and GUI. The participants insisted on the fact that the GUI should allow more direct manipulations, and on the fact they need more assistance in the process of solving educational inconsistencies.

We can draw several conclusions from the analysis of the tracks collected to test the second assumption. On the one hand, the assumption is supported by the analysis of the scenarios provided by the participants because they are rather usable with students. On the other hand, the assumption is also supported by the analysis of the responses of the participants that are considering the scenarios usable.

8. Conclusion

Despite the small number of participants and that several indicators rely on their claims, the results of our experimentation give some insight on the design of APPLiq and MoPPLiq.

The analysis of the tracks of the participants shows that a graphical representation such as MoPPLiq helps them understand the scenario of an SG (assumption #1) and supports the instrumentation process (Rabardel, 2003). The analysis of the scenarios made by the participants shows that APPLiq enables them to design scenarios that are usable with students (assumption #2) and thereby that instrumentalization (Rabardel, 2003) of SGs is possible. These results regarding our assumptions #1 and #2 are interesting because they allow us to conclude that APPLiq is involved in SG appropriation by teachers. Indeed, on the one hand, APPLiq helps them understand and master the SG. On the other hand, it enables them to adapt the SG to their educational needs. MoPPLiq and APPLiq are contributions to meta-design that enhance appropriation of SGs by teachers, and may also support their adoption.

The results also draw new avenues of research for APPLiq. Thus, we are working on new support systems to help teachers to manage educational inconsistencies. We are also working on tools to help them assess the quality and the relevance of the scenarios they are working on. We are introducing new features related to the GUI that provide some more direct manipulation. And finally, we are working on the features that some participants suggested such as a timeline of the scenario objectives.

In a broader sense, the work presented in this paper shows that on the one hand it is possible to provide meta-design tools to help teachers to master and adapt SG scenarios to their needs. On the other hand, it shows a reproducible example of a remote experiment to inform the design of such tools.

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What is a Game for Geometry Teaching: Creative, Embodied and Immersive Aspects

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Abstract: Game based Learning (GBL) has been promoted as a way to enhance science, technology, engineering and mathematics education, in several aspects. In this paper we aim at conceptualizing the creative, embodied and immersive potentials in the context of teaching geometry in primary school. We review two cases where the concept of "game" is related to the development of pupils' creativity and innovation skills. One intervention is inviting pupils to become designers at a "game factory", by using the digital mathematics tool GeoGebra. The second intervention uses mobile technology to have students participate in a collaborative game requiring them to take part in an embodied activity outside the classroom. In the paper we develop a model that view game based creative learning in as a combination of constructive, immersive, and reflective aspects. We do that by considering different meanings of the word "game" in a mathematics education context. That is game as a medium, game as a framing of educational processes, and games as an object. Considering games as media highlights the similarities with texts and any other means of delivering content. We can ask what message a specific game conveys, and discuss how well suited the game is compared to other mediations of the same content. Games can be described a as "semiotic domains" that allow players to interact with knowledge and make sense of the world (Gee, 2003). Games can act as a framing used to govern and plan educational processes, either as direct motivational driver, aiming at engaging more students in certain planned activities (Hamari, Koivisto, & Sarsa, 2014), or as an established form of process control in which complex situations can be played out. In a game the player act according to rules and the process has a natural direction towards finishing or advancing in the game. Furthermore games can frame educational processes by challenge the learners perspective through narratives and role-playing (Shaffer, 2006). Pupils creative design competencies and motivation to create and develop games have been documented as unusually relevant and high (Kafai, 1995; Tekinbas, Gresalfi, Peppler, & Santo, 2014). Mathematical thinking s can be used to think game scenarios through, to govern the competitive aspects of a game and ensure that the gameplay is fair and balanced in terms of the involved struggle. Game literacy, both in terms of playing, producing and discussing games, does thus relate to mathematical literacy and knowledge.

Keywords: serious games, embodiment, epistemic games

1. Introduction: Game oriented learning and STEM

The use of educational games is a promising path to enhance science, technology, engineering and mathematics (STEM) teaching. It is argued that such games can motivate, engage, provide students with relevant educational experiences more in sync with the competences needed in society and allow for better learning process. However many of the educational products that builds on game mechanics are often criticized for being mere edutainment in the sense that they combine an entertaining gameplay with simple root learning tasks providing classical curricular content. Hence the relation between games and STEM education is richer than providing a competition and narrative around drill and practice activities or immersing students into role playing activities.

The main problem that we address in this paper is how we should understand the many possible relations between games and STEM education. We challenge the naïve idea that games is a (perhaps very good) substitute for genuine teaching, and we use two cases of game related activities in the area of geometry to develop a conceptualization of the ways that games relate to STEM education, with a special focus on embodiment and innovation. Hence we will attempt to approach game based learning in a much broader fashion than games as instrumental learning machines. Simultaneously we aim at focusing on specific aspects of learning (creativity and embodiment) and specific topics (geometry), in order to develop a situated understanding of what game oriented learning can be. After a brief state of the art on games, mathematics, embodiment, and creativity, we present two cases of geometry teaching where the relation between embodiment, creativity and immersion are different. Following this case description we develop and discuss a model for game oriented STEM learning distinguishing the various roles of game as medium, framing, and object.

2. Games, mathematics and creativity

Computer related activities that enhance collaboration and learning are often referred to as computer supported collaborative learning activities (Koschmann 1996). In this tradition Shaffer (2006) has developed the concept *epistemic frame* to describe how participants in a practice develop shared ways to view the world. Taking a sociocultural approach this framework distinguishes between skills, knowledge, identities and values as pragmatic categories that describe an epistemic domain. Furthermore this framework introduces the notion of epistemic game as a "*game that deliberately creates the epistemic frame of a socially valued community by re-creating the process by which individuals develop the skills, knowledge, identities, values and epistemology of that community*" (Shaffer, 2006). Shaffer's framework combines investigation and understanding of practice and design of learning material (epistemic games) that uses this practice to formulate learning.

The van Hieles have made an extensive work on understanding the nature of geometrical thinking (van Hieles cited in Clemments; 2003). They distinguishes four levels of geometrical understanding 1) Description (being able to distinguish and somehow talk about shapes), 2) analysis (being able to distinguish shapes according to defining properties, 3) Abstraction and 4) Proof. This framework suggest that a profound knowledge on the lower stages (1 and 2), is a necessary prerequisite for developing the higher levels of geometric thinking.

Kress and van Leeuwen (2001) define multimodality as "the use of several semiotic modes in the design of a semiotic product or event, together with the particular way in which these modes are combined." In traditional teaching there has often been a dominance of writing, and verbal communication, but the use of new media in learning makes it possible to integrate other modalities in the design of learning, and explore their potentials for engaging and motivating the learners. Other forms of knowledge are predicated on the representations and modes, enabling learning in different ways, that may be relevant to the learner within different frames, as Kress suggests (2009) "there is no meaning without framing".

The embodied nature of mathematical thinking and the formation of mathematical concepts have been investigated and discussed thoroughly in the mathematics education community, and among philosophers of mathematics. Some philosophers and cognitive scientist argue that mathematics is in fact an output of human cognition and the way humans with bodies acts in and experience the world (Lakoff and Nunes, 2000). Yet others consider this analysis superficial because it does not reflect the extent to which mathematical activity demands deliberate cultivation of analytical thinking styles, and hence are very different from what could be considered a natural mode of thinking (Leron & Hazzan 2006). Disregarding this controversy there is a consensus that experience with mathematical phenomenon's does have some value in mathematical concept formation.

From a didactical/educational point of view this philosophical controversy is not so much over whether or not bodily activities are relevant in mathematics education, as it is a discussion about whether or not such bodily activities should always be complemented by an analytical approach.

Developing mathematical creativity with students is an important ambition in mathematics education, however mathematical creativity can be considered as *with* or *within* mathematics, meaning either creativity as using mathematics as tool to express oneself, or developing solutions valued as creative within the field of mathematics as a school discipline or scientific discipline. And furthermore two basic metaphors exist for mathematical creativity, namely construction and problem solving (Misfeldt, forthcoming).

3. Case one: Creative digital mathematics

The research and development project "Creative Digital Mathematics" (Misfeldt & Zacho, forthcoming) aims to develop and implement a new approach to the introduction of digital mathematical tools to introductory and middle schools students. The research explores potentials in using the children's creative competencies as a vehicle for teaching skills with mathematical tools. Furthermore the intervention challenges the students' conception of teaching and learning of mathematics, towards a more free and student driven situation. The project follows the ideas of Papert (1980) as well as the ideas in game based learning intiteled "scenario based education" (Hanghøj 2011, Misfeldt 2015). In the intervention we aim to develop mathematical learning environments that allows pupils' to work with digital media and mathematical representation allowing them to appropriate GeoGebra to their own need.

The project has been running from March 2011 to June 2014, and been through four cycles of design and intervention ((1) one grade 5 class, (2) two grade 3 classes, (3) 40 primary school teachers and (4) 40 secondary school teachers). In each intervention, students have developed board games or other visual structures using the tool GeoGebra (see Hohenwarter & Jones (2007) for a description of the tool).

The pupils' work is organized by a simple web based interface, and starts with a few simple drawing tasks, continues to solve a number of mathematical tasks before they start developing their project.

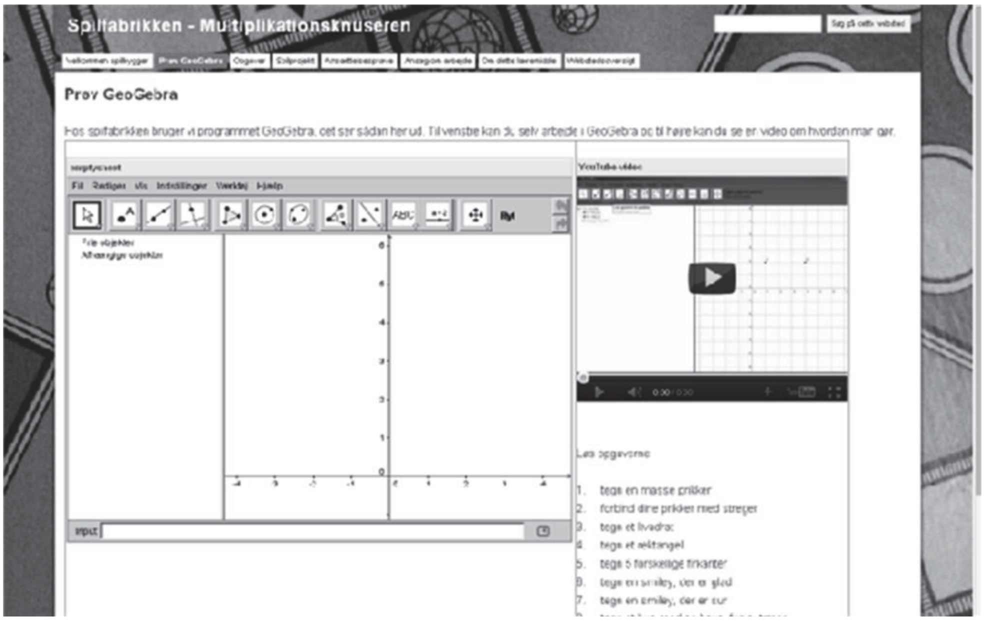

Figure 1: Screenshot from "multiplication crusher" with tasks (text field, bottom left), video-introduction (top left) and an embedded GeoGebra workspace

The data we have consist of the teaching materials developed by the teachers, together with the material, the teachers also provided a description of learning goals and a detailed description of their intentions with the material, student products, observations of 50 lessons, and interviews with eight students (see Misfeldt & Zacho (forthcoming) for a description of how this material is analyzed),

The pupils were able to take control over the software and appropriate it to their needs. Given that this intervention was the first meeting with the GeoGebra for most pupils, the age of the pupils (promary and middle school grade 1- 6), and the time used with the project (approximately ten lessons), we do consider this a good result.

In both design/intervention cycles all pupils developed a game. Most, but not all, games had some mathematical theme. Designing board games was accepted as a meaningful activity by almost all children.

The interviews with pupils (Rosenkvist, 2012) revealed that the pupils considered their work as mathematical work. The pupils in general felt that the mathematics classes where much freer, building more on their own ideas.

Through the interventions we have realized that there is a strong benefit from structuring the students' work with a digital learning environment, both for the pupils whos learning is structured, but also for the teachers who are able to articulate their ideas about digital mathematics teaching in a collaborative way..In that sense the project uses the teachers competencies as didactical designers as a vehicle to introduce ICT in mathematics teaching. Since the teachers take part in the design of the learning environment the project attempts to capitalize on teachers' creativity in order to change teaching and learning of mathematics towards including digital tools.

4. Case two: Mobile learning environments

The research and development project "Mobile Learning Environments" has explored the use of a mobile game prototype "MathX: The Search for Ancient Wisdom" in the teaching of mathematics for students age 14-16 in the Nordic schools. The project has developed a game for learning mathematics in secondary school, and subsequently implemented it on 3 different mobile platforms, which have been tested with learners in different educational settings. The platforms range from a conventional Mobile phone to Smartphone, to a Sensor-based platform.

The project was conducted in collaboration between Nordic partners from Universities as well as industry partners, like Nokia. The research involved user-tests done on location in classrooms and outdoor areas in Denmark, Sweden and Finland where the game was used as an intervention in the math-class. The research design used a mixed-methods action-research approach, and included pre- and posttest questionnaires, as well as video-observations and interviews with students and teachers involving three schools in the three Nordic countries. The study involved a class in each of the schools with students grades seven to nine. The material was subsequently analyzed in order to understand the affordances of a mobile game-based learning environment in relation to the learners' experience of engagement, motivation and their modal preferences for learning. The research method allowed for triangulation of the data from the surveys, observations and interviews, thereby strengthening the validity of the findings.

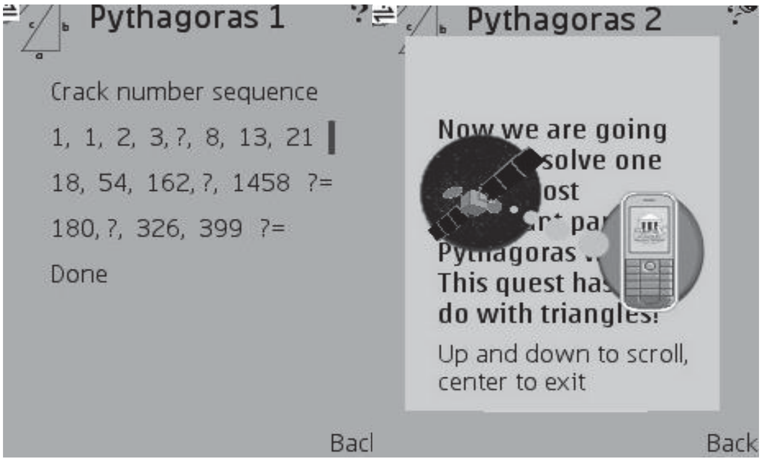

Figure 2: Screen-shots from the mobile game on Pythagoras, where tasks had to be solved in order to move forward in the environment

The mobile game and the narrative about Pythagoras in which it was embedded as a quest for solutions to problems, provided an experiential framework for solving tasks that were contextually anchored in the physical environment and added a potentially affective dimension to the learning situation. The teachers also reported this experience of the learners' engagement as a positive outcome of using this mobile game-based approach. This "fun-factor", which some of the students reported made learning math into something much more enjoyable and tangible than they had ever experienced before, according to the qualitative data and the data from the questionnaires.

Figure 3: A collaborative learning situation in the gameplay

The design of the mobile game prototype "MathX: The Search for Ancient Wisdom has implemented theories of collaborative learning and is supposed to be played in groups of three to four students, depending on the mobile device used. The results from the questionnaires and the qualitative interviews after the game play tests, showed that the experiences with the game led to a more positive attitude towards collaboration, and that the majority of the students perceived themselves as fully involved in the work of the group. Field observations, however, showed that not all learners were involved in the actual problem solving in the group, something which the game-design in a further development should seek to scaffold through developing user roles that offer adequate challenges to all players.

From the observations and interviews in relation to the testing it was obvious that the majority of the learners enjoyed the experience of working in a mobile game-based learning environment. The analysis of the data from all three countries showed that the affordances which the game-based mobile learning environments were providing the learners were related to:

- The collaborative learning which provided a setting for social interactions
- The multiple multimodal representations
- The game-embedded learning environment
- The context sensitivity
- The portability of the devices supporting learning situations outside the classroom
- Framing of physical activities, that allowed for measuring, and moving about

These affordances are important factors to consider when developing or evaluating math in game-based mobile learning environments.

In the previous sections we have shown examples of game related educational activities that are different from sugar coated drill and practice exercises. We will use these examples as an outset of a discussion of the possible roles of games in teaching and learning of mathematics. This discussion is organized around two main themes; (1) understandings of what games are and can be considered in mathematics education (as medium, framing and object), and (2) theoretical conceptions of the learning potentials in games.

The resulting picture reveals a broad scope of educational possibilities related to the uses of games in mathematics teaching. The result of the analysis can be seen as a first attempt to untangle this range of possibilities.

5. What is a game in mathematics teaching and learning

In the following discussion we take three different approaches, considering games as a medium for delivering content, as a framing that governs and communicates a certain process, and as an object for students and teachers to develop, discuss and analyse.

5.1 Game as medium

Considering a game as a medium highlights the similarities with texts and any other means of delivering content. This is perhaps the most mainstream and important way to look at the educational potentials of games. We can ask what message a specific game conveys, and discuss how well suited the game is compared to other mediations of the same content. James Paul Gee (2003) describes games as "semiotic domains" that allow players to interact with knowledge and make sense of the world. In Gee's educational vision games in general and videogames in particular are considered media that the player "reads/consumes". Since a game is often read/played in a far more interactive way than texts in other media, there are specific learning potentials related to games. This idea is followed in Devlin's description games as a world where all sorts of mathematical phenomenon's cam be conveyed.

In both of interventions described we can consider the involved games as media. In the creative digital mathematics project students develop games conveying knowledge about multiplication, and they work in a game like on-line learning environment designed to convey knowledge about multiplication and the uses of the digital tool GeoGebra. In the mobile learning game the content of the game is even more explicit, as the game had a storyline about Pythagoras, which connected to the tasks that had to be solved to advance in the game. The game was multi-modally (Kress 2003) mediated through different mobile devices and tangible it-artefacts which allowed for learning through haptic feed-back to the solving of mathematical problems linked to Pythagoras and the game -play was supported by audio and visual storytelling on the mobile devices.

The mobile game then functioned as a medium for multi-modal learning, enabling the learners to engage with mathematical learning drawing on their literacy about the multi-modal game medium. It is clear that a view of games as media for delivering content does not take all aspects of the game medium into account – especially the interactivity and feedback possibilities. These interactive possibilities are a natural aspect of games considered as media as described by Gee (2003).

5.2 Game as framing of educational processes

Apart from games being a medium with some specific interactive, motivational and mathematical aspects, games can also be used to govern educational processes. Games can be used as a mean of controlling and driving complex educational activities. This didactical potential has several aspects. Games can be used as a direct motivational driver, aiming at engaging more students in certain planned activities. Furthermore games are an established form of process control in which complex situations can be played out. In a game the player act according to rules and the process has a natural direction towards finishing or advancing in the game (even though students also might just wander off exploring the environment). Finally games can challenge the learners' perspective through narratives and role-playing. This potential been investigated by David W. Shaffer (2006), and according to him games allows students to act through an epistemic starting point different from their student perspective.

The learning potentials of students designing games for each other has been looked at in a study by Gjedde, Horn, Sørensen (2011) exploring the use of students design of a learning game for energy awareness. It found that it framed the students' reflection on a content level as well as at an aesthetic level, and that the process of designing the game called for a greater level of cognitive involvement than playing the game.

In the creative digital mathematics project students engage in an epistemic role playing game, and in that sense they act as designers rather than students of mathematics. This reframing allows students to develop products (board games) that are not mathematics per se, but does activate and draw on mathematical skills and competences.

In the Mobile Learning Environment the framing potential is even more explicit. The advances made in the game allow students to engage in curricular activities while they simultaneously are participating in a location-based game. Without the gameplay the motivation for and direction of the educational process would be hard to maintain, and the process would be difficult to control and facilitate for the teacher.

According to Klopfer (2008) mobile games can be used to tackle real world problems in a playful environment, a frame in which the situated complex and dynamic problem-solving challenges and motivates the learner to develop scientific argumentation.

5.3 Game as an object

Apart from delivering content and governing classroom processes games are objects themselves. This means that games can be used in education as object for analysis, as something students develop and even as an educational deliverable. In the project "Creative Digital Mathematics" we use the pupils creative design competencies and motivation to create and develop games (previously investigated by Kafai (1998)).These games are products that have a height level of mathematics in them. Mathematics can be used to think game scenarios through, to govern the competitive aspects of a game and ensure that the gameplay is fair and balanced in terms of the involved struggle. Game literacy, both in terms of playing, producing and discussing games, does thus relate to mathematical literacy and knowledge, and it is important to include this aspect in the curriculum and learning designs.

6. Learning potentials

In the following we will focus on some of the potentials that games have for providing a learning environment that includes creativity, embodied cognition and collaboration.

6.1 Bridging mathematics and creativity

In the Creative digital mathematics project we use the potential of games as an object to ask students to make games, and hence to work in a creative way and use mathematical concepts. In order for the pupils to view themselves as working in a creative way, we also use the potential of (role playing-) games as a framing to allow the children to participate in a different practice inspired by professional design activities

Games have the potential of reaching between the realm of human experience and aesthetics on one side and numbers, calculations, balance, and geometric shapes on the other side. Working with games, pupils can activate several modes of thinking in their creative process and also get a feel for the real life applications of mathematical competencies that are linked to a very engaging and creative learning experience.

6.2 Activation of embodied cognition

Playing games does often combine the kinesthetic dimension with the cognitive and this makes the game format well suited for framing processes that enhance the embodied nature of mathematical thinking. In the mobile learning game the participants are explicitly pushed towards exploring mathematical problems with their bodies. We argue that the game framing adds meaning and recognition to these activities. The van Hiele theory of geometrical thinking shows the importance of grounding higher conceptual thinking in very concrete tactile conceptions of the geometrical shapes. Games can play an active role in that process. Firstly games allow the teaching and learning of geometry to be more spatial and embodied by bringing the students out of the classroom as seen in the Mobile Learning Environment project. This process has the potential of providing the necessary grounding of the geometrical concepts. In the Creative Digital Mathematical project the children used mathematical software to develop a visual and interactional project. In order to make the visual shapes that the students care for they need to refer to the definitions (for instance by creating a circle using center and radius. This process has the potential of moving up the van Hiele levels towards the analysis and abstraction level.

6.3 Enhancing collaboration

Games are often connected to collaboration, where players are collaborating in teams in order to solve problems and advance in the gameplay.Teams and opponents are a natural aspect of playing games, and hence framing an activity as a game can constitute these roles. Furthermore pupils development of games as (partly mathematical) objects, can be a way of ensuring that students with different interests can have something meaningful to collaborate on.

Games can be a vehicle for Problem- Based Learning (Savery & Duffy 1996) ,which is an approach to learning with a focus on learning through the solving of relevant problems, rather than through a presentation. In relation to this games can be understood as frames for the collaborative problem-solving that anchors the problems in a fictional setting that can be very engaging for the learners.

Table 1: The three conceptions of game in geometry teaching

	Bridging mathematics and creativity	Activation of embodied cognition	Enhancing collaboration
Medium	The expression through the medium of game calls for creativity as well as mathematical competencies	The medium can combine the kinesthetic dimension with the cognitive	Games can be a medium for collaboration through the gameplay
Object	Games as objects serve as bridge between mathematics and creativity		Games can be the objects of shared reflection in a group of learners
Framing	Epistemic games can frame creative problem solving	The game can frame activities of embodied cognition	The shared framework supports collaborative workflow by the learners

7. Conclusion

In this chapter we have explored two cases where a combination of Game Based Learning with a creative, collaborative and embodied pedagogy has presented an alternative approach to the teaching and learning of mathematics. We have developed a conceptualization of how games can be conceptualized in STEM learning situations, as either; medium, frame or object. Furthermore we have distinguished learning potentials in relation to these ways of thinking about games.

We have pointed to some approaches that may frame learning designs that enhance collaboration in the classroom while bridging mathematics and creativity.

In order to explore the learning potentials of this approach further, more research should be done focusing on the process of the learners' game-creation as well as the parameters for the learning design of mobile games in education.

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Implicit and Explicit Information Mediation in a Virtual Reality Museum Installation and its Effects on Retention and Learning Outcomes

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Abstract: Much research is currently being done in the area of Virtual Reality. This is due to the imminent release of several new pieces of gaming hardware that promises to bring the Virtual Reality (VR) experience into the homes and public spaces of ordinary people. This study attempts to build on the established literature to create a new form of game-technology based museum learning experience which uses VR to give the user a chance to visit the past. Greve Museum has been looking for a new way to visualize historical places like Mosede Fort, an old World War I battery south of Copenhagen in Denmark and the application developed for this study is a game-based Virtual Reality experience, which places the user at this Fort during World War I using the Oculus Rift Head Mounted Display. The application development was based on theories from other works concerned with education theory in games as well as engagement theory. The experiment explored the amount of knowledge retained, depending on how the information was mediated through the game. One version of the game had all the information given by a narrator and the other worked entirely through dialogue and other diegetic sources. The findings indicate that the implicit procedure only was a tad better suited for information retention overall, but that the explicit procedure gave the user a chance to gain better understanding of the situation. The study furthermore leads to several areas of discussion; partly how the setup affected people positively but also possible future aspects for the implementation.

Keywords: mediation, VR, museum, engagement, HMD, learning, game technology

1. Introduction

Recently Virtual Reality (VR) has become more widespread and accessible to the common consumer. This study is therefore looking into the idea of using this VR game-technology as a tool for teaching. How to increase the learning outcome of such experiences, especially with all the stimuli a user gets from a Virtual Environment (VE), is the main focus of this research. The authors of this study created a Virtual Reality Environment that transported people back to the time of World War I (WWI) as seen from the Danish fortification, Mosede Fort. This location was chosen because a partnership was already established with the museum as they were looking for new ways of engaging their audience. The focus of the study then was to assess the usefulness of implicit information mediation, where the environment and the characters in the VE were used to convey said information. This study looks into the differences in effectiveness, on retention and learning outcomes, between explicitly and implicitly mediated information. What effect does these methods of communication have on the user's ability to remember facts? The results from the experiment indicated that the implicit procedure was more suited for information retention.

2. Background

Based on results from a previous investigation (Warming et al, 2013), which regarded attention guidance in VR, this study is attempting to observe whether explicitly presented data and use of narrative devices to impart data implicitly, has the same effect on the retention of information that the user experiences. Therefore, a clear definition of the terms implicit and explicit in the context of this study is needed. Bordwell, Thompson and Ashton (1997) describe diegetic and non-diegetic as two different methods of communicating information. Information is diegetic if it exists within the confines of the fictional universe like dialogue between characters and items within the virtual environment. Non-diegetic information describes other artefacts or sounds such as narrators or floating guide arrows originating from outside the virtual environment. Within the context of this study, implicit information mediation is thus considered to be diegetic to its environment. This means that the mediating element is not alien to the environment and is therefore part of the world. Explicit information mediation, by contrast, is considered to be non-diegetic to its environment. For example the narrator, who is not physically present in the environment but mediates information directly to the user.

2.1 Educational games and learning

Research suggests that it is possible to learn from games when focusing on computer games in an educational context in general. However, Egenfeldt-Nielsen (2006) criticises that many researchers tend to focus on examining if it is possible for games to be effective teaching tools, instead of focusing on investigating whether the results gathered from games differ from other methods of education. The effectiveness and requirements might vary substantially from traditional learning. He further divides educational games into several categories: Edutainment, Commercial educational and Research-based educational games. The current study works with elements from the latter.

These games have a more academic background, with well-founded documentation for learning outcomes, as they have been designed on the basis of edutainment research, and are intended to confront current construction of traditional education. Research-based educational games are developed to integrate educational learning goals by facilitating intrinsic motivation through internal rewards like fun and accomplishment instead of prizes and point scores. Consequently, gameplay should lead to a heightened level of engagement due to its focus on the players learning and playing experience (Schoenau-Fog 2012). Yet, research-based games are often economically limited to low budgets and therefore often also miss the technical quality to compete with the commercial games.

2.2 Engagement

The indication of the previous study was that people who showed interest and were focused, remembered more of the facts imparted to them during the test (Warming et al, 2013),. Engagement theory describes the different reasons for why people ”get into” different media and activities. O’Brien and Toms (2008) created a model for engagement that outlines different aspects of creating an engaging experience, consisting of the broad categories of ”Sensual”, ”Emotional”, and ”Spatiotemporal” engagement. Sensual engagement is what a user hears and sees, and how they interact with the medium. Emotional engagement is the state of the user’s mind as they interact with the medium. Spatiotemporal engagement is the current situation of the user in the real world. Each of these have triggers for engagement and disengagement.

Engagement can come from many places and the current study is focusing on the use of narrative engagement in particular. Schoenau-Fog and Bjørner (2012) describe narrative engagement as instilling curiosity in the user through cues and other narrative devices such as suspense or story-arcs. This encourages the user to experience the story to completion and this may subsequently motivate them further to pay closer attention. Narrative engagement might be used as a way of increasing the amount of information a user retains after the experience as an improved substitute for narrators, facts and figures.

2.2.1 Narrative engagement and learning

Several studies have been conducted concerning the use of narrative as a learning tool; especially in games. Rowe et al (2010) tested the edutainment game “Crystal Island”, a narrative-centered educational software focusing on middle school microbiology. They found that students that were engaged learned more, independently of their prior knowledge of the subject. Rowe et al also mentions off-task behaviour as an indication of disengagement where the user might become bored or distracted. Monitoring off-task behaviour might be a good idea for any test looking into engagement in players. Dede (2009) talks about transfer, the process of taking something learned and applying it, and how it can be measured with sequestered problem-solving or preparations for future learning. While that study focuses on immersion, engagement is still a important part of that and thus narrative plays an important role. Rowe et al and Dede both found that an engaging experience increased learning and transfer.

2.2.2 Suspension of disbelief and the Magic Circle

Adams and Rollings (2006) state that in order to enjoy and follow a narrative the recipient must be in the right state of mind. An important aspect of an engaging narrative is having the user willingly suspend their disbelief and enjoy the story being told. If a user keeps getting distracted by unrealistic or unbefitting circumstances or badly spoken dialogue in the narrative they might experience disengagement. All steps should be taken to make sure the narrative stays believable and that the voice acting lives up to the same standard. It might be possible to command more suspension of disbelief from the user by maintaining a magic circle. When a reader opens a book or the curtains unfurl at the theatre the audience makes a pact with the artist; that they will believe what they are about to experience long enough for it to affect them emotionally. This is one way to explain the magic circle that has been used since our ancestors sat around a fire, telling stories, 50.000 years ago (Adams and Rollings, 2006). A clearly defined magic circle might help the user to "enter" the virtual world and suspend their disbelief. The user must play along and pretend what they are experiencing is real to a certain degree. This is also an important requirement, when developing virtual environments for VR museum installations.

2.3 A model of engagement

In order to get an overview of the engaging qualities of a game-technology based virtual environment experience, a model (Figure 1) specifically designed for learning and accounting for narrative engagement was developed based on O'Brien and Toms (2008). It is important to keep in mind a variety of parameters when designing a game that has to be both educational and engaging and the model has thus been used as a foundation for the design of the VE. The model defines points that get the player engaged, keep the player engaged and a point that,may disengage the player from the game - it is however possible for the player to become re-engaged after a point of disengagement.

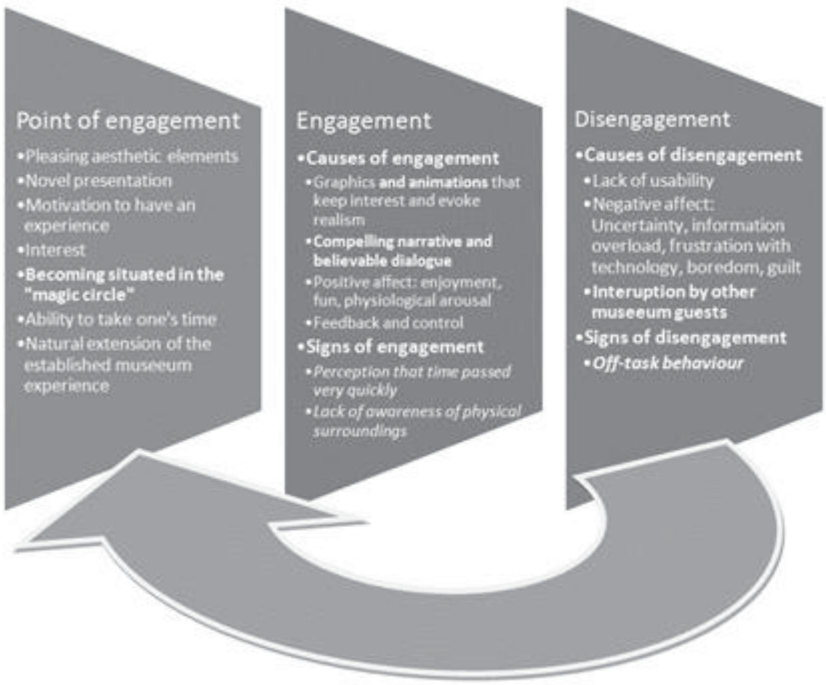

Figure 1: A model for tracking the cycle of engagement and the different aspects which influence it. Based on the model by O'Brien and Toms (2008). The points in bold are specifically added for this study

2.4 Narrative museum experience scale (NMES)

Since this study focuses on interactive narrative content in museum installations, it is valuable to investigate the possibilities for evaluating such experiences. Othman, Petrie and Power (2011) developed a scale to measure visitors' experience in museums called the Museum Experience Scale (MES). This scale helps to get a clearer understanding on how visitors interact with artefacts and exhibits and it gives a valuable empirical evaluation of visitor experiences. Participants were asked to rate statements in four different categories stating their level of agreement on a Likert rating scale from 'strongly disagree' to 'strongly agree'. The four categories are as follows:

- *Engagement*, with exhibitions or exhibits
- *Meaningful Experience*, gained from understanding and information discoveries
- *Knowledge/Learning*, from the interaction with the exhibitions/exhibits or other visitors
- *Emotional Connection*, with the contexts and contents of the exhibits/exhibitions

Since this study also has a focus on narrative engagement, the original MES will be used as a foundation for a new set of questions: the Narrative Museum Experience Scale (NMES). Busselle and Bilandzic (2009) designed a questionnaire for measuring narrative engagement in linear media, such as film or radio dramas; it tests for multiple aspects ranging from empathy to transportation in the sense of having a change of place illusion, and it would be relevant for testing the same aspects for this study. The questionnaire consist of the same Likert Scale design as the MES, where participants rate statements on a 'strongly disagree' to 'strongly agree' Likert scale. Care must be shown when translating the questions to interactive non-linear media due to the fact that information is not provided in a set order. Table 1 contains a list of the questions used for the NMES.

3. Methods

In order to test the difference in retention, based on the implicit and explicit mediation of information an experiment was designed with the following hypotheses:

> *H_0: There is no significant difference between the participants' level of retained information, when presented with information either implicitly/explicitly.*
>
> *H_1: There is a significant difference between the participants' level of retained information, when presented with information either implicitly/explicitly.*

3.1 The experiment

In order to test the difference in retention based on the implicit and explicit mediation of information, an experimental research design was developed. Using the Oculus Rift VR HMD and the game development tool Unity, a virtual environment depicting Mosede Fort in Denmark as it looked during World War I, was created. In this VE there were several objects that the user could look at. This caused the objects to light up and activate a sound sequence that would then mediate a piece of information relating to the object, the fort or Denmark during World War I. Two versions of the VE were created. The first version mediated the information in an implicit way, where information for example was mediated in a conversation between two soldiers. The second version mediated the information explicitly using a narrator and pictures that would appear in the user's field of view. The VE had a total of 8 objects that could meditate information. A screenshot of the VE can be seen in Figure 2. Questionnaires were used to gather information after the experience; one using the NMES to determine engagement levels and one that tested the participants’ knowledge about World War I and Mosede Fort.

Figure 2: The virtual environment as seen on a normal screen. Soldiers are looking at the Zeppelin as it approaches the coast

3.2 Experiment design

As the target group includes everyone, who would have an interest in museum exhibitions, participants were chosen using convenience sampling and were all in the age group of 19-31. They were speaking fluently Danish and had not participated in any higher education of history. The participants were randomly divided into two groups; the control group who received the information explicitly and the treatment group who received the information implicitly. Prior to playing the game, participants completed consent forms, which informed them of the possibility of simulation sickness. They were also consenting to being video recorded during the experience. Participants were also informed that they would have to answer factual questions about what they had learned after the experience.

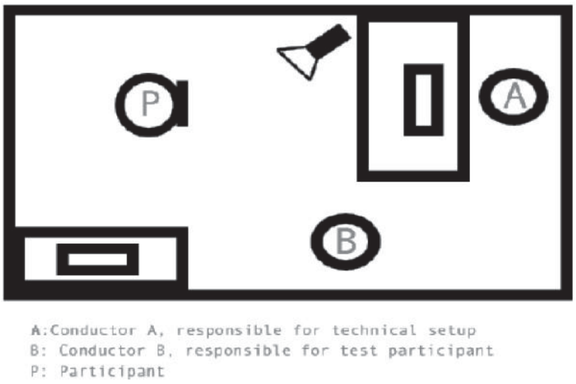

Figure 3: The setup allows for a test conductor to completely focus on the technical aspects to ensure that everything runs smoothly

Apart from the participants, two test conductors were also present in the room during game play. One was responsible for the technical side of the experiment, while the other was responsible for noting general observations and assisting the participants throughout the experiment. Subsequently, participants completed questionnaires, which was conducted in another room. Both the explicit and implicit participants received the same questionnaire. This helped to2 minimize possible bias due to difference of phrasing. The room setup can be seen in Figure 3.

Table 1: Examples of questions used to gauge participant learning outcomes. (F) indicates a factual question and (U) indicates a question of understanding

A. What year was the Versailles Treaty signed? (F)
B. What did the Versailles Treaty involve? (U)
C. What was the reason World War One started? (U)
D. What year did World War One start? (F)
E. What year did the fighting end? (F)
F. What was the Danish state asked to do, by Germany, in the beginning of World War One and what did this lead to? (U)

3.3 Results

The test was completed by 40 participants, with 20 in each group. The implicit mediation of information testing group had 9 males and 11 females, while the explicit group had 17 males and 3 females. The average age of the participants were 23.7 years in the range 19 – 31 years. As a maximum score, each of the two groups could obtain 520 points combined if each participant got all 26 questions correct.

Table 2: Total points for each group

	Gained points	Percent correct
Explicit group	213	41%
Implicit group	173	33.3%

The 26 questions were divided into two categories that were factual and understanding, depending on their focus. Table 2 and 3 highlights the scores achieved through the two mediated categories.

Table 3: Points as distributed between factual and understanding questions

	Possible points	Gained points	Percent correct
Explicit group			
Factual questions:	320	125	39%
Understanding:	200	88	44%
Implicit group			
Factual questions:	320	93	29%

	Possible points	Gained points	Percent correct
Understanding:	200	70	35%

During the testing a bug in Google Drive's form application caused a loss in data from the explicit test population. Only 10 participants got to answer the Narrative Engagement questions. The following table is still included for comparison, but the narrative engagement part should not be counted as valid. The questions presented were requiring answers in Likert scales ranging from 1 to 10.

Table 4: Combined Likert scale scores of each group on the NMES

	Explicit	Implicit
Engagement:		
''I enjoyed the experience''	7.7	7.7
''I felt I experienced Mosede Fort during WWI''	6.3	6.1
''The experience was interesting''	7.7	8.5
Meaningful Experience:		
''I reflected upon the life at MF in WWI''	5	4.7
''I was satisfied with my experience''	7.3	8
Knowledge/Learning:		
''The information provided was clear and understandable''	8.1	6.8
''I liked the graphics and sound design''	7.1	7.1
''I learnt new things about MF and WWI through my experience''	7.4	6.5
Emotional connection:		
''The experience was a reminder of the history of Denmark''	7.3	7.2
''I felt more present in the experience than in the real world''	6	6.9
''I was overwhelmed by my experience''	6.1	6.6
''I felt connected with the experience''	6.3	6.7
Narrative Engagement:		
''I listened to what was said''	6.1	5.6
''I was surprised that the experience was over so quickly''	5.1	4.9
''At times I forgot I was part of an experiment''	5.3	5.1
''I felt like I was part of the story''	4	4.7
''It was difficult to focus on the experience''	5.2	5
''I could easily follow the events that were occurring during the experience''	7.4	6.8
''At times I found it difficult to follow what was going on''	4.2	4
Averages of the scores of the two groups	6.29	6.26

3.3.1 Observations and comments

Based on the video recordings and observations, the frequency of off-task behaviour was very low and limited to the users testing the HMD and its capabilities. There were no off-task behaviour due to boredom or disengagement in general. Participants were asked what they believed made them remember some information better than other information. Several participants (n=7) noted that they were too enthralled by the environment to notice the information that was presented to them. Another participant wrote: ''Very nicely designed (both image and sound), which had a large influence on my concentration and the value of the experience. The information was combined naturally into the experience, which made it not seem intrusive or artificial - that was very important to my experience.'' - translated from Danish.

3.4 Findings

Wilcoxon rank-sum test of the answers from the questionnaire of historical questions returns a P-value of 35.54% meaning that we can not reject the null-hypothesis of there being no significant difference between the learning outcome of the two versions of the product. No statistical analysis was made on the NMES questionnaire because of loss of data. However, there are indications that the results are similar in the two experiences.

A point worth noting is that the questionnaire testing the participants' knowledge on Mosede Fort and World War I showed that questions about very dynamic events were easier for the implicit group to answer than the explicit group. The implicit group had the events played out with animations and sound while the explicit group had it explained to them by a narrator. The difference is most marked in a question involving a German Zeppelin flying over the fort and the soldiers responding to that. “What situation at Mosede Fort, could have resulted in Denmark entering the war?” was answered correctly by 12 from the explicit group and 18 from the implicit group. Another question “What type of military equipment was made more reliable and therefore more used during World War One?” was answered correctly by 9 from the explicit group and 15 from the implicit group. This indicates that dynamic events may lead to the participants having a better understanding along with a better recollection of what happened. The level of detail of the answers given by the implicit group, especially for the zeppelin event, was also much higher that the other group.

4. Discussion

The findings indicate that using diegetic events may be useful to help people retain information about events. More detail may be remembered and in general a better understanding of concepts are shown in the answers. Purely factual questions about dates and years were more difficult to retain. This indicates that if it is the facts that are important they could be given directly to the player instead of being hidden in dialogue. In the following, we will summarize and discuss the findings and aspects of the study.

4.1 Using the Oculus Rift in general

While this project builds on studies done with Virtual Reality, this technology is still very new to the majority of people, and it remains to be an unknown territory to the average person (it will become available to the general public within the next year). This means that while this game-based technology can create interest in the user, it might also be the source of unintentional distraction. On several occasions, test subjects commented that there were several moments where they did not pay full attention, because they were deeply engaged in admiring the Oculus Rift VR technology. In the coming years more and more people will get the opportunity to try a VR experience, and they will most likely be more used to the technology and pay more attention to the content of the experience.

4.2 Considerations concerning the information mediation

The purpose of this study concerns mediation of information inside a virtual reality in regards to supporting retention. The mediation of information was divided into two types. One type was explicit and non-diegetic, while the other was implicit and diegetic. The final experiment of this study did not find differences between the two setups that were significant enough on a large scale. However, answers to the individual questions asked in the questionnaire, reveals that larger differences are evident. When studying some of the answers given in the test, several of the factual questions were answered more precisely by participants using the explicit setup. Furthermore, one certain episode, such as the Zeppelin event, gathered better results in the implicit setup than in the explicit. A reason for factual data seeming to work better in the explicit setup could be, that people are trained to listen to a narrator, as opposed to a conversation. Another reason could be, that participants were simply distracted by the voice-acting in the implicit setup. The 2D images, used by the explicit version of the game, could be a good way to inform the participant that they are learning, and that they should be relating this experience to actual historic events. This could have been a factor during the experiment. It should also be noted that the explicit group and a larger group of males than the implicit group, while this may not have an effect it should be noted.

4.3 Users’ comments on what helped them remember

During the questionnaire part of the experiment sessions, the participants were asked, what helped them to remember the information during the session. For the Implicit version there is a pattern, which indicates that participants had a hard time remembering the factorial information (such as dates, names ect.) but that they remembered events and conversations better. In the Explicit version, participants commented that information with closely related objects, like the calendar and the map of the fort, helped them remember the information. Some comments that were repeated in both versions were that participants had a hard time paying attention and when the participants could relate to the information they could remember it better – the price of the soldiers’ cigarettes were a popular example. This should also be seen in relation to information which participants could link to their own life and experiences.

4.4 The users' experience and learning outcomes after using the installation

One of the main issues when testing was that the experience of trying out the novel VR game technology seemed to outweigh participants' focus on the educational purpose of the experiment. In other words, the mediation of information was affected significantly by the overall experience. This relates closely to the idea stated by Egenfeldt-Nielsen (2006), that a research-based educational game designed, based on a cognitivist theory which work to facilitate intrinsic motivation, will lead to a strong sense of player experience, where the player will focus more on the game play than the educational content gained from the game. This indicates, that when working with VR, one must be aware of the risk that the educational outcome can be drowned out by player experience and a possible high level of engagement. Therefore, the combination of fun and learning must be carefully considered, in order to not exclude one for the other.

5. Conclusion

An important challenge while testing for differences within virtual reality, especially with an installation supposed to be entertaining, is the novelty effect and the people who respond to this by being unable to concentrate on the content. We hope that VR technology will keep increasing in popularity and some day people will be as acclimatized to it as they are to TV. Even though this study has shown indications that there are strengths in both implicit and explicit mediation of information, with a small advantage to implicit, we conclude that it will be difficult to get real data on the effectiveness of learning through VR, as long a the novelty of VR is as distracting as it currently is. However, the novelty factor might play in favor for a real installation at the Mosede Fort exhibition as it might just draw in people with its novelty factor and only later begin to impart knowledge like it was designed to do. In terms of which mediation method is best for teaching history when working with game-based technology, it is important to remember that these are tools to be used in combination and that one is not necessarily more effective than the other. If it is an understanding of a specific situation that you want to convey, then it seems like doing it with dynamic and diegetic events is a good strategy.

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The Predator Game: A web Based Resource and a Digital Board Game for Lower Grade School, Focusing on the Four Biggest Predators in Norway.

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Abstract: The Predator game was developed by Nord-Trøndelag University College, The Mid-Norway Predator Center and the game company AbleMagic. The game is a multiplayer digital game, based on a classic boardgame model, where the players take on roles as one of Norway's four biggest predators, the bear, the wolf, the lynx, and the wolverine. The goal is to use the game as a part of grammar school children's preparations for visits to the Predator Center and the learning activities that they organize. This paper describes testing the game on a group of grammar school pupils. It focuses on how different game properties and the surrounding context effects the gameplay, looking into indicators like motivation, collaboration and competitiveness. It shows that The Predator game engages pupils and enhances collaboration and that the pupils genuinely appreciate many of its' features. At the same time it reveals some weaknesses in the game design as well as technical flaws. As digital games are a powerful medium for teaching and learning, proper testing during the design stage is essential. This paper lays out the strengths and the weaknesses of The Predator game, enabling improvements at the same time as sharing our findings with other game designers and scholars, in order to facilitate successful game design.

Keywords: digital, board, game, Predator

1. Introduction

Norwegian children are no different from their international peers, they like digital games. Roughly nine out of ten Norwegian children within the age group of nine to sixteen play digital games in their spare time and their access to different types of devices is increasing (Medietilsynet, 2014).

Educational games are increasingly being employed into schools to renew and vary the pedagogical learning activities (Rosas et.al, 2003). The predator game project was initiated in 2013 in collaboration with the Predator Center in Namsskogan (Norway) and the County Administration. Originally this project was a part of a bigger project, called "Living with predators", in Lierne municipality. The main objective was to give local people a better understanding of the biggest predators, as many expressed fear towards them. The main goals of the project were: Teaching kids to love nature; Maintain the quality of life that nature gives; and damping the people's fear toward predators.

The Predator Center in Namsskogan played an important role, with their expert knowledge on the themes of predators in general. They have also taken part in developing pedagogical courses directed towards lower grade schools. The project group concluded that a digital game would be an engaging and fun pre-visit activity for the pupils to improve preparations for visits to the predator center and their one-day-course on predators. The Norwegian game Company *AbleMagic* has, in collaboration with the Game development department at the Nord-Trondelag University College and the Predator Center at Namsskogan, developed this game with the aims of increasing the attention toward and the understanding of the biggest predators in Norway.

This paper is organized as follows. An insight into previous research and theoretical background describes how digital games might improve motivation for learning, through different kind of factors. We then describe the game and methods for collecting empirical data. The findings are presented and then discussed in the following sections. The last section concludes the paper.

2. Conceptual framework

Originally, digital games were mainly played outside the academic environment, but in the past decades digital games have been gaining acknowledgement as a teaching tool, as recent and current trends in education call for a step away from traditional teaching methods (Van Eck, 2006). The behaviorist approach on teaching focuses on stimuli and response as the core of learning. Although many educational digital games for learning embrace the elements of behaviorism, the general trend to increase the variety of teaching approaches, without ruling out more "traditional methods" works in the favor of digital game-based learning (DGBL) (Tomlinson, 2001; Egenfelt-Nielsen, 2006; Zevin, 2007).

> *We learn from games quite differently than we do from news and books. We also learn from games quite differently than we learn from school where failure is a big deal. Not so in games; just start over from the last save. A low cost for failure ensures that players will take risks, explore and try new things (Gee, 2010, p. 52).*

DGBL has been shown to have great potential, as a tool that facilitates learning through trial and error and as a powerful motivating force. When successfully employed digital games can keep the pupils interested and motivated to explore, tackle challenges and overcome various obstacles. Elements such as "fun", "competition" and "engagement" should not be underestimated in an educational context (Gee, 2010; Van Eck, 2006; Nejem & Muhanna, 2013). Collaboration and co-operation are also widely acknowledged in that regard (Gee, 2003; Dooley, 2008).

> *However, collaboration is more than co-operation. Collaboration entails the whole process of learning. This may include students teaching one another, students teaching the teacher, and of course the teacher teaching the students, too. More importantly, it means that students are responsible for one another's learning as well as their own and that reaching the goal implies that students have helped each other to understand and learn. (Dooley, 2008, p. 21).*

It is furthermore well established that motivation in itself affects the learning process. Thomas Malone (1981) developed a model to look for motivation in games and to see what components makes it fun to play. His main focus was on the theory of intrinsically motivating instruction, finding the three indicators *challenge*, *fantasy* and *curiosity* to be the most important ones. Mozelius (2014) tested the Taxonomy of Interpersonal Intrinsic Motivation (IIM) - from the work of Malone and Lepper (1987) and found it to be very a useful taxonomy for increasing the students' motivation. The Taxonomy of Malone and Lepper (1987) defines two variables for measuring IIM. These are "Internal motivation" and "Interpersonal motivation". The factors "challenge, curiosity, control and fantasy" were used to measure the variable Internal Motivation. To measure the variable Interpersonal Motivation, they used the factors "cooperation, competition and recognition". Scoring high on these factors implicitly means that the effect on IIM is significant and that the game is motivating.

Yee, et al (2012, p. 2804) defined an interesting Online Game Motivation Scale, based on a 3-factor model, measuring different aspects of the three factors: "social", "immersion" and "achievement". Their findings show that the "social" factor is measured with elements like chatting with other players, being part of a guild, grouping with other players and keeping in touch with your friends. The immersion factor is measured with elements like learning about stories and lore of the world, feeling immersed in the world, exploring the world just for the sake of exploring it and creating a background story and history for the character. The achievement factor is measured with elements like becoming powerful, acquiring rare items, optimizing your character as much as possible, competing with other players.

3. Testing the game

The Predator game is a digital turn-based board game, aimed at the age group 8-12 year olds (3. - 6. grade). It is inspired by classical board games, using "chance"-cards, assignments, maps and contents. The contents include three mini-games, each focusing on a particular topic: hunting, recognizing animal tracks and excrements. It all happens in the vicinity of the Børge mountains (Børgefjell). The player plays the role of a bear, a wolf, a lynx or a wolverine and to win the game he/she needs to find food, solve puzzles and given assignments, and find his/her mate. The players are not able to see what assignments the other players have or what level the other players are at. But they can see where the other players (animals) are in the overall map.

Figure 1: Main page of the Predator game

The main educational goals of the game are to make the pupils more curious towards what a predator is, what it looks like, what it eats, how it lives, etc. Enabling both an exploration of the world of the Børge mountains, as well as playing the more instructional mini-games, the predator game can be said to be both explorative and instructive. It has been under development for over a period of 1,5 years and has been tested by both users and experts during the development process. The first version of the game was defined finished in the spring of 2015.

By testing the Predator Game and how it is played we wanted to find out how the game and the learning situation supported the above mentioned indicators, looking for factors like: challenge, fun, curiousness, competitiveness, collaboration, etc.

The study was conducted with 3 separate groups of participants, each with approximately 22 pupils, in primary grades 4-6. All of them were on their way to visit The Predator Center and learn more about the predators. The pupils came from 2 different primary schools, one (Group 1), a small private school with a group of 22 4th-6th graders, and the other from the public school system with 44 5th graders. The latter class was subdivided (into groups 2 & 3) to facilitate observation. Two different locations were used for the study, the private school, and the HiNT University College, the researchers' home base.

Group 1 was exposed to the game in their home school. The school's network firewall would not allow the multiplayer online version to be played on separate computers, so it was decided to test it as a turn-based game, with up to 4 players sharing a computer, with each student taking their turn in the presence of the others. The set-up was similar to a board game. Group 2 was observed in a college computer lab, in much the same manner as Group 1, with sub-groups huddled around one computer. Group 3 was also observed in the college lab, however, each pupil was assigned to an individual computer, so they could play individually, instead of in a group. Network firewalls still prevented play as multi-player online, so each pupil would play all 4 characters, taking all the turns themselves.

The study took place between March 2015, and June 2015. Data was collected using a trifold approach consisting of visual observation of student behavior; questionnaires filled out by the pupils upon completion of the test period, and semi-informal plenary interviews with the pupils concerning some general features of the game and the experience. Group 1 played for 2 hours, with a short break after one hour. Groups 2 and 3 played for 1 hour each. Observational data was recorded throughout the process. Two researchers were present at each testing session to gather data, and observe the pupils. The questionnaires included both Likert-scale questions and open questions. In all there were 66 participants, however only 64 questionnaires were returned to the observers.

The visual observation primarily targeted the physical behavior of the pupils as they played the game in various configurations, with an eye towards attention span, and any outward signs of cooperation and competition. The questionnaires targeted specifics about the game and its gameplay, what they liked and what they disliked. The aural poll targeted achievement and motivational information.

4. Findings

The results from the questionnaire shows that the pupils are satisfied with the digital game. Out of 64 participants, 94% felt it was exciting and that they would like to play more. 77% agreed with the statement that playing the game made them forget about time and 89% agreed that it was fun to play the game. These findings are further backed up by our observations – which showed that the pupils were deeply engaged when playing the game and seemed to enjoy it. The question then is: What made the game fun to play?

During the observations we were aiming to see what motivates the pupils when playing the game. Observations revealed a considerable amount of cooperation. The pupils showed each other how to play the game, even though they were playing against each other. Several pupils also mentioned cooperation as a positive side of the game, in the plenary interview at the end of the testing session. The dynamic behavior in the groups during the testing showed energy and enthusiasm – both towards solving individual assignments in the game and helping the other players solving their assignments in the game. The collaboration and social aspects of the game situation evidently played an important role in the play and the engagement towards playing the game. Even when group 1 was given a 10-minute break, all of them were back playing the game within 2-3 minutes, on their own initiative. Visual observation of group 1 further revealed that pupil attention and interest was strong and continued to be solid until the end of the session, with pupils losing interest only after almost 2 hours of gameplay.

It was also observed that the small group concept fostered a considerable amount of collaboration, with all participants involved in gameplay, regardless of whether it was their turn or not. The pupils were actively participating in each player's turn, pointing to various areas on the screen, and vocalizing suggestions for game moves. Visual observation of Group 2 yielded similar results, although a few of the pupils seemed to lose interest earlier, apparently because of losing their game, and feeling left out of the group dynamics. When these pupils regrouped and started a new game, it resulted in a renewed interest in the game. Group 3's results were somewhat different. They were also the only group that played individually. Their attention and focus started slipping steadily after just 30 minutes. By the end of the 1 hour session, roughly half of the last group had lost attention and focus on their gameplay. However, the plenary discussion following gameplay, revealed that group 3 had a higher level of achievement in terms of the game level attained, than the previous groups.

One of the open questions on the questionnaire involved naming the three things the pupils liked the most about the game, as well as the three things they disliked the most. On the things they liked the most, "being an animal", "hunting", "finding things (food)" and "solving puzzles (mini-games)" were the most common answers. Other frequently mentioned elements were "increasing the skills level", "learning about the animals" and "winning". "Playing with friends" was also mentioned by a few. The plenary discussion round further confirmed this.

From the list of things they disliked, the most frequently mentioned elements were "animal dying / losing" (meaning the player is out of the game), "game crashes", "bugs (technical flaws)", "not being able to fight against your competitors" and "not being able to choose your animal". The results from the questionnaires supported our observations. The participants evidently enjoyed things like hunting, solving puzzles, exploring and increasing their skills level. Verbal comments like "Oh, the mini games are fun to play" and "Yeah, I've increased my skills to level 5" were recorded during the time of the observations. On the more critical side comments like "Strange that I can die while I'm asleep", "It's boring to sit and wait because I (my animal) died ", "It crashed again" and "Wish I could re-appear" were registered.

The observations also revealed technical challenges, as the game crashed on several occasions and the pupils had to start all over again. In spite of the technical flaws, the majority of the kids really did enjoy playing. We also observed that the pupils liked exploring the Børgefjell world and that they were intrigued by the short mini games.

5. Discussion

The exploratory nature of the Predator Game was central to its acceptance by the pupils. Competitiveness seemed to be enhanced by collaboration, as is common in many “team” sports. That competition allowed some to reach the highest goals, while spurring the less competent to achieve average to better than average results.

Group 3 showed somewhat different results than groups 1 and 2. They had a shorter attention span, yet higher achievement levels. This was the only group that played individually. It is possible that their attention may have shifted to a curiosity about how their other classmates were faring. Screen peeking and physical movement from one station to another started at the 30-minute mark. A possible explanation is their natural tendency to be social, or feel more comfortable in a group dynamic. It could also be a gauging mechanism to measure their own progress against the progress of others. Some measure of interaction is foreseeable, even in individual play. Their higher level-achievement rate could indicate that individual effort produces greater results than group effort. Perhaps individual players have faster gameplay, as mistakes made in previous turns can be corrected more easily, and they have the ability to be the animal (player) with the highest score at any given time. It also needs to be considered that some overzealous pupils had a propensity to exaggerate their achievement in aural polling.

Our findings support the writings of Malone and Lepper (1987) and Yee, et.al (2012). Mozelius (2014) writes about Interpersonal Internal Motivation as a key factor for increased engagement towards playing online games. The table below shows our findings categorized in the style of the Taxonomy of IIM, made by Malone and Lepper (1987).

Table 1: Comparing our findings with Malone and Lepper (1987)

Internal Motivation	**Challenge**	**Fantasy**	**Curiosity**	**Control**
Findings	Hunting, Eating, Finding Things, Solving Puzzles, Increasing the skills level, Doing assignments	Being an animal	Exploring, The fog, Roll the wheel, Animal tracks	Being able to move in different directions

Interpersonal Motivation	**Competition**	**Cooperation**	**Recognition**
Findings	Hunting, Surviving, Reaching new levels, Winning	Playing with their friends	Helping their friends achieving

Further the next table shows our findings categorized in the Online Game Motivation Scale from Yee et. al. (2012).

Table 2: Comparing our findings with Yee, et al (2012)

Motivational factors	**Achievement**	**Immersion**	**Social**
Findings	Hunting, Eating, Finding Things, Solving Puzzles, Increasing the skills level, Doing assignments, Increasing the skills level Reaching new levels , Winning	Being an animal, The fog,	Helping their friends achieving, Playing with their friends

Comparing our findings with Malone and Lepper on one hand and Yee on the other hand supports their models. It underpins the fact that a lot of the elements within the Predator game positively effect the players’ motivation. It also supports the observations, showing pupils that are motivated and eager when playing the game.

Also, important to notice are the critical comments from the participants. These can be divided into two main categories; design flaws and technical flaws. “Animal dying” means the player loses the game and hence is out of the game. In many games, the player can reoccur if he/she dies. This is not possible in the current version of the Predator game, and it seems to be a drawback. While a designer of a commercial game may have good reasons for not giving the player the opportunity to reoccur, an educational game is different. As the main goal is to engage for increased learning outcomes the game design should assure that the players are kept in the game, and if they "die" – they should be given the opportunity to reoccur. If not, this challenges the whole idea of using games to enhance learning. Another design flaw was that the player could not return to the path that he/she had been walking on earlier. In some cases, this led to the player being trapped within his/her own tracks / path, as he/she was not able to move further. Again, this might be deliberate within a commercial game, but for an educational game, keeping the pupils engaged is essential. Our data suggests that pupils need to be given the opportunity to stay within the game. The technical flaws were "bugs", such as problems with catching things that the player was meant to catch, that food "hidden" under a prey was inaccessible and inadequate accuracy in fight mode. Another kind of technical flaw was the game crashing and having to be restarted.

6. Conclusion

Based on our research, we can see that our Predator game has the ability to engage pupils for at least an hour at a time. When played in a group setting, where there is a high degree of collaboration, the focused exposure time can be increased. We were pleased with this result, as we believe that keeping the pupils engaged is crucial in an educational game. The longer they remain engaged, the greater chance there is that the pupils will gain some knowledge of the subject matter.

We also found that there are certain mechanisms within the game design that can either promote pupil focus, or detract from it. The pupils recognized several positive design features, such as exploration, mini-games, and the fantasy of being an animal. They also pinpointed certain design elements that had a negative effect on their gaming experience. These include early player death with no recovery (lost game), inability to retrace steps, leading to entrapment, inability to choose the animal counterpart, etc. Although these may be worthy challenges in a commercial game, they represent an impediment to educational goals. The technical challenges that were revealed are also of importance, as we have found that teachers often mention this as a main hindrance in the integration of DGBL.

Consequently, we find that educational games that are designed to be played in groups stand a better chance of maintaining student interest and attention for a longer period of time, and that educational games that center around achievement and degrees of "win", without an absolute "loss", may keep the engagement factor high, encourage student involvement, and aid the chances of the absorption of subject material.

For future work, comparing the multiplayer version of the game with the single-player (in groups) version of the game would add to the picture, and so might some detailed research on the group dynamics and collaboration for the enjoyment of and the motivational aspects of playing the game. Our findings also call for more research on the long-term use of the game, to see if the game loses it's motivational qualities as time goes by. Furthermore, testing the game in another context might yield in valuable results, examining, for example if the game is as engaging when played solely for fun as when it is a part of a preparation to visit The Predator Center.

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Non-Digital Game-Based Learning in Higher Education: A Teacher's Perspective

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Abstract: Game-based learning (GBL) is a new educational paradigm. Digital game-based learning (DGBL) is a well established teaching pedagogy in higher education; commonly referred to as a GBL. However, there are many non-digital educational games available which do not require any technological assistance. Non-digital game-based learning (NDGBL) has also many advantages over digital game-based learning in education. Nonetheless, the teacher is the most important part of successful implementation of any DGBL or NDGBL approach. Teachers' perceptions are crucial towards this type of innovative learning because teachers are a bridge between students and games. Many studies were conducted that presents teachers' perceptions on the more popular form of GBL, DGBL approach. There are very few studies presenting teachers' perceptions on NDGBL. Therefore, in this paper, I present teachers' perceptions on my proposed NDGBL approach. This paper provides a critical analysis of teachers' feedback who played non-digital mathematical games to test the effectiveness of my proposed NDGBL for adults in higher education.

Keywords: non-digital game-based learning, NDGBL, GBL, maths game, mathematics, higher education, teacher's perspective

1. Introduction

Game-based learning (GBL) has been an efficacious way of teaching in education. Digital game-based learning (DGBL) is the more popular form of GBL; learners, teachers, and researchers often take this to be synonymous with GBL *tout court*. However, the less popular but deep-rooted form of GBL - non-digital game-based learning (NDGBL) has also been a vital part of our teaching tools in education (Eck 2006, Hamey 2003, Naik 2014a, Naik 2014b, Walsh 2013, Whitton 2012).

GBL is a popular and prevalent teaching aid in the classroom. Many teachers either accept or support this technique for teaching directly or indirectly. Notwithstanding, teachers' perceptions to use this GBL are very crucial in the success of GBL. As such, a powerful GBL without the teacher's intelligence and interest may not be able to provide desired outcomes. Therefore, it is essential to investigate teachers' perceptions in adopting this GBL approach. Teachers' general perceptions towards GBL are overwhelmingly positive and they think GBL is really helpful in motivating students in their academic learning (Fengfeng 2008, Inamdar and Kulkarni 2007, Perrotta et al. 2013, Watson et al. 2011). Some teachers are more affirmative and they think playing games can support the development of a variety of skills (Foreman et al. 2004, Prensky 2001, Quinn 2005, Watson et al. 2013).

There were various surveys conducted to determine teachers' perceptions about DGBL (Weareteachers 2012, Wastiau et al. 2009, Sandford et al. 2006, Schrader 2006) and mostly confirmed the above said achievements of GBL. However, teachers' perceptions of using games for education may be influenced by various internal factors: creativity, experience and skills in technology, and external factors: others' perceptions, policies and curriculum (Bourgonjon et al. 2010, Koh et al. 2011, Naik 2014b). Some teachers even considered games a distraction to students (Pastore and Falvo 2010). Therefore some teachers have a reserved attitude towards the adoption of games for teaching for various reasons. Moreover, the negative perceptions pose barriers to the adoption of games in classrooms (Watson et al. 2013).

In the light of teachers' perceptions about DGBL, it is equally important to evaluate teachers' perceptions about the use of NDGBL. NDGBL has many advantages over DGBL, including: cost effectiveness, low administrative overheads, little or no learner and teacher skills required, and it provides opportunities for enhanced social interaction (Hamey 2003, Eck 2006, Naik 2014a, Naik 2014b, Mustafa et al. 2011, Whitton 2012).

In this regard, I developed the non-digital game-based learning (NDGBL) approach (Naik, 2014a) to teach mathematics to undergraduate first-year computer science students. The main aim was this NDGBL approach to dispel the fears of mathematics form students who lacked experience of formal instruction in mathematics at intermediate or higher levels. Also to motivate and encourage them for learning and enhancing their mathematical skills. This NDGBL approach was deployed as a co-instructional strategy to complement the classroom teaching.

Student feedback and learning-outcome attainment measurements provide evidence that NDGBL both motivates learners and makes a positive impact on learning outcomes. Furthermore, it is possible that the pedagogical usefulness of these games is not limited to mathematics; they might readily be adapted for the teaching of other subjects. Having developed this, I decided to analyse teachers' perceptions on my NDGBL approach. Subsequently, I played my teaching games in two workshops in two different conferences with wider teaching community. In this paper, I have critically analysed teachers' perceptions on my NDGBL approach based on feedback collected in the conferences.

The remainder is organized as follows: a literature review on teachers' perceptions towards DGBL (Section 2); a brief description about proposed non-digital game-based learning (NDGBL) approach (Section 3); an investigation of teachers' perceptions about proposed NDGBL which includes (a) a presentation of how teachers played these games at conferences and (b) an analysis of teachers' feedback on NDGBL (Section 4); a critical evaluation of the findings of Section 4 (Section 5); a discussion of the limitations of this research work (Section 6); and finally some concluding remarks (Section 7).

2. Teachers' perceptions towards DGBL

In the last two decades, game-based learning has received significant attention as a way to motivate students and engage them with their academic learning. In the promotion of this innovative GBL approach teachers play a very important role. Teachers' perceptions are crucial towards this type of innovative learning because teachers are a bridge between students and games. Many studies were conducted that present teachers' perceptions on popular form of GBL i.e. DGBL approach.

In general, most teachers think that games motivate and engage students in learning and that playing games can support the development of a variety of skills such as problem-solving skills, perseverance skills, technical skills, social skills (Weareteachers 2012, Can and Cagiltay 2006, Foreman et al. 2004, Koh et al. 2011, Prensky 2001, Quinn 2005, Razak et al. 2012, Sandford et al. 2006, Wastiau et al. 2009, Watson et al. 2013).

Weareteachers (2012), an online resource for educators, surveyed 309 K–12 classroom teachers from public, private and religious schools, and Wastiau et al. (2009) surveyed more than 500 teachers in several European countries about their perceptions of using GBL; both found that more than 60% teachers use any form of GBL (non-digital or digital games) in the classroom. Sandford et al. (2006) conducted a survey of 924 primary and secondary school teachers in England on their attitude towards the use of commercial-off-the-shelf (COTS) games and found that more than 60% teachers considered these are helpful in teaching and improve students' skills.

A teacher's perception of using games for education may also be influenced by internal and external factors to him or her. Internal factors may include: creativity, experience and skills in technology, training, personal interest and attitude towards gaming and external factors may include: others' perceptions (such as those of students, parents, other teachers, and experts), policies and curriculums, administrative and management support, IT infrastructure (Bourgonjon et al. 2010, Koh et al. 2011, Naik 2014b).

However, the majority of teachers view digital games as a useful tool in the classroom, the tool to be utilised by mostly skilled and creative teachers (Pivec 2009, Prensky 2001). Most of the teachers are using or willing to use games in the classroom but do not think that GBL can replace teachers (Prensky 2001). Some teachers even considered games a distraction to students (Pastore and Falvo 2010). Therefore some teachers have a reserved attitude towards the adoption of games for teaching due to various reasons (Razak et al. 2012, Wastiau et al. 2009). Consequently, the negative perceptions of teachers can pose barriers to the adoption of games in classrooms.

3. Non-digital game-based learning (NDGBL) approach

The non-digital game-based learning (NDGBL) approach (Naik, 2014a) was developed to teach mathematics to undergraduate first-year computer science students. These group of students lacked experience of formal instruction in mathematics at intermediate or higher levels. Therefore, the main aim of this NDGBL approach was to dispel the fear of mathematics from students and to motivate and encourage them for learning and enhance their mathematical skills. This NDGBL approach was deployed as a co-instructional strategy to complement the classroom teaching.

In the development of this NDGBL, I sampled and analysed a series of popular and inexpensive games such as: rummy, bingo, sudoku, anagrams, scrabble, jigsaws, crosswords, tic-tac-toe, snakes and ladders, darts, backgammon, ludo, logo, monopoly, soroban/suanpan, and reversi with a view to adaptation. I adapted a number of games which I could closely match with the topics of my mathematics curriculum and found most suitable during my initial investigation period. Finally, I developed the following games: arithmetic-fractions rummy; a decimal crossword puzzle; a logarithmic and exponential jigsaw; an algebraic equations bingo; a binary-to-decimal conversion magic box and a decimal-to-binary conversion magic box (Naik 2014a).

I employed this NDGBL to teach mathematics to first-year computer science students and played all games with students through the support of my colleagues. Later, students' feedback and learning-outcome attainment measurements provided evidence that NDGBL both motivated and made a positive impact on learning outcomes. Additionally, it is possible that the pedagogical usefulness of these games is not limited to mathematics; they might readily be adapted for the teaching of other subjects. Many colleagues from my department and university took part in the implementation of this NDGBL approach and provided valuable feedback to me about my NDGBL approach.

4. Teachers' perceptions towards NDGBL

As a teacher, I appreciate that teachers' participation and suggestions are always a key factor to analyse the success of any new teaching project. Although I received feedback from my colleagues within the department and university, I wanted to assess my NDGBL approach among the wider teaching community across the HE sectors. Therefore, I decided to present workshops on my developed non-digital games in the conferences so I could gather more feedback from experts of different disciplines, universities and industries.

4.1 Teachers' articipation in NDGBL

I presented two workshops in the two different conferences: 1) "Take It Easy, It is Games Not Mathematics", in HEA-FD-2014, on 2-3 April 2014 (Naik and Price, 2014c) and 2) "Do Not Teach Mathematics, Play With It", in AULTC14, on 16-18 September 2014 (Naik, 2014d). In my game play at conferences, I maintained consistency in both of the workshops and played a similar game, "arithmetic-fractions rummy", with conference delegates. I also designed similar questionnaires for both the workshops and gathered feedback from all participants so I could analyse it as a bigger data set.

The game "arithmetic-fractions rummy", played at both conferences is developed to teach the mathematical topic 'arithmetic operations on fractional numbers', which students find difficult to grasp. In this game, I created a deck of 54 playing cards along with a rules-sheet. The deck consisted of 34 cards bearing fractional numbers, and 20 cards bearing arithmetic operators (including those for addition, subtraction, division, multiplication, and equality). Fractional numbers were selected such that it would be possible to construct a large number of arithmetic equations. Before game-play, the rules of the game were explained and rules-sheets were distributed to the conference delegates. All the conference delegates were divided in to the groups of four in which each player was dealt seven cards.

The game plan was simple: a series of rounds were played in each of which the winner was the first to construct a valid arithmetic equation and the overall winner within a group was decided on the total of rounds won. The round winner's score was the result of that valid equation (i.e. the numeric value on the right hand side of the equation). Typically, time was allotted in the conference to allow for five rounds to be played. After all the rounds were completed, winners were identified and prizes distributed. Subsequently, they completed the given questionnaire and also gave some oral feedback.

4.2 Teachers' feedback

Teachers' feedback was elicited through a questionnaire which allowed five possible responses to a series of propositions: Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. This questionnaire format was chosen in order to determine whether teachers found this approach useful or not; only if they did would further time and effort be devoted to the development of the approach on wider scale in HE. A summary of the feedback quantifies teachers' perceptions on various aspects of the non-digital game-based learning (NDGBL) approach is shown in Table 1. I put seven questions to the 52 experts from the various fields who played games in the conferences. The questions concerned learning, motivation, online/digital version and the use of NDGBL.

Table 1: Teachers' feedback summary

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q.1: Would you prefer GBL in HE learning and teaching	19.22%	80.78%	0.0%	0.0%	0.0%
Q.2: Do you think GBL is helpful in academic learning	17.31%	82.69%	0.0%	0.0%	0.0%
Q.3: Do you think playing games is more interesting than teaching in classroom	46.15%	46.15%	7.70%	0.0%	0.0%
Q.4: Do you think GBL is helpful in motivating and engaging students	48.08%	50.0%	1.92%	0.0%	0.0%
Q.5: Do you think physical games are easy to learn and equally good as technology-based games	84.62%	15.38%	0.0%	0.0%	0.0%
Q.6 Do you think prizes in games are motivational	26.92%	61.54%	11.54%	0.0%	0.0%
Q.7: Would you like to see online/ digital versions of these games	0.0%	34.61%	61.54%	3.85%	0.0%

The overall response from the subject experts in both conferences is quite positive and reaffirms students' feedback gathered in the past. Question 1 was the most crucial question in terms of knowing their reservation about this new way of teaching because they have the ability to promote any new teaching approach in HE. If they did not like it then it would be difficult to pursue this approach on a wider scale in HE as their support would be required. Fortunately, All conference delegates who played games supported this new way of teaching.

As the general perception is that digital games outperform over on traditional games. The response to question 5 (100% agreed) was a big breakthrough for me to continue my NDGBL work in the HE sector. Nobody thought that digital games are better than traditional or physical games; that is reflected from the responses to this question 5. Surprisingly, feedback of question 7 from teachers showed that they are more interested in my old fashionable non-digital games rather than high-tech digital games. Of those teachers questioned, 88.46% do not want to see the transformation of these non-digital games into digital or online games. This reflects that perhaps teaching community is more concerned about the side effects of digital games and benefits of the social networking.

Favourable responses to questions 2 and 4 (100% and 98% agreed respectively) underscore the potential of NDGBL. Teachers endorsed the research literature that this approach is helpful in academic learning and that playing games motivates learners (Fengfeng 2008, Inamdar and Kulkarni 2007, Perrotta et al. 2013, Watson et al. 2011). Therefore, they think this approach may be another way in HE to motivate in other difficult subjects and reinforce their learning. Positive responses to question 3 (92.3% agreed) endorsed that teachers think playing games in the classroom is more effective than more traditional teaching methods. The question 6 (88.46% agreed) echoed that teachers also think distributing prizes is a token of achievement in their learning that makes the overall gaming environment more stimulating.

5. Discussion

It is crucial to analyse teachers' perceptions in embracing and promoting this practical NDGBL approach in HE. In this regard, the current study is performed to investigate teachers' perceptions about quite different GBL, that is based on simple and traditional games rather than popular digital games. In this study, the teaching community overwhelmingly supported this new NDGBL approach for teaching in HE. The tremendous positive response of the teacher to NDGBL showed that the proposed GBL approach has a place in higher education and has the potential to prove very successful. Interestingly, teachers do not feel the need for an online or digital version of this non-digital game-based learning approach. However, they would like to see a more enhanced version of the existing approach and have many opinions/suggestions about current games. Thus, this study evidence clearly shows that teachers feel this proposed NDGBL approach is effective in learning and should be used more widely in higher education.

6. Limitations

This NDGBL is undergoing various experimental stages and feedback led improvements until it reaches maturity. This study is one of the many stages of this development process where it has attracted the teaching community and received valuable feedback on game design and game instructions, playing times, curriculum alignment, new games for more topics, teacher's role, university support, etc. This study was performed in the two workshops in the conferences to obtain feedback from diverse HE community. The feedback showed substantial support and perceptions of the diverse teaching community; however, participants were neither mathematics teachers nor mathematics experts so their perceptions and suggestions may be profoundly based on their areas of expertise. Therefore, it may be more useful to examine what mathematics teachers specially think about this NDGBL approach to teach mathematics. Also the study is more of an initial exploratory study because the sample size of participants was small.

7. Conclusion

This paper has presented the investigation of teachers' perceptions about my own non-digital game-based learning (NDGBL) approach to the teaching of mathematics in higher education (Naik 2014a). Initially, I have expounded literature on teachers' perceptions towards DGBL. Subsequently, a similar study was performed to determine teachers' perceptions towards my proposed NDGBL approach. In this regard, I presented two workshops to demonstrate and play my own developed games with HE teachers in two different conferences – HEA-FD-2014, on 2-3 April 2014 and AULTC14, on 16-18 September 2014 respectively. I chose the same game- "arithmetic-fractions rummy" and same questionnaire for the both conferences so consistency would be maintained in the analyses. Subsequently, teachers' feedback was obtained through a questionnaire of seven questions.

The overall response from the subject experts in both conferences was quite positive (more than 85% agreed) and reaffirmation of students' feedback gathered in the past. All conference delegates who played games supported NDGBL and recommended its use in HE. The most astonishing response was for question related to online/digital version of this NDGBL approach; 88.46% teachers do not want to see the transformation of these non-digital games into online/digital games. This reflects that teaching community is perhaps more concerned about the side effects of digital games and the benefits of social networking while playing non-digital games. However, this study is more of an initial exploratory study on teachers' perceptions about this NDGBL approach because the sample size was small and not all conference delegates from the mathematics field. Thus, in the future it would be useful to investigate a larger sample size and exclusive mathematics teachers' perceptions about this NDGBL.

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How can Teachers Develop Pervasive Games for Learning?

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Abstract: This project describes how teacher students and third year bachelor students in games and entertainment technology use a Concurrent Design Process (CCD) to develop a pervasive game to use in education. The case studies are based on projects carried out in Nord-Trøndelag University College (NTUC) and Hedmark University College (HUC). At NTUC the first part of the project took place in the fall of 2013 in a course on Game Based Learning (10 ECTS), where the teacher students developed different concepts for pervasive games for teaching in elementary school. The main competence of the students was pedagogy and practical teaching, so the pervasive game development had to be taught before the development process started. The given assignment was simple; develop a concept for a pervasive game for use in the classroom. The teacher students made six different game concepts in total during this assignment. The second part took place in the fall of 2014, and this time third year bachelor student from the games and entertainment technology track was given one of the game concepts developed in the first part by the teacher students, and was asked to improve the game concept. This assignment was designed as a short CCD-process, where the students improved the pervasive games, and suggested new ICT-related ideas and digital support. Students were organized into four groups of six students, and the groups were put together as heterogeneous as possible. In each group, the students had different roles in order to maintain creativity throughout the development process. In HUC, students from the game development tracks did the first pervasive game development in 2012, and then later the idea was transferred to the teacher education program as a 30 ECTS course in the 4th year in 2014/15. The game development track and the teacher education program were separate development processes and not connected. We suggest a new model for the preproduction process using a concurrent design process. A CCD process can give a better structure using working sessions and collaborating tools for the work process. Further, a CCD process involves students with different background and competence, and the students get specific roles and perspectives like teacher/user, game designers, storyteller, programming expert, project leader and others. The goal of the work is to develop a game design document and a project plan for developing the game.

Keywords: gamification, games and learning, pervasive games, digital games, concurrent design

1. Introduction

Callele divide the production process of video games into two phases as described in figure 1 (Callele et al, 2005). First the Preproduction phase where the students develop a game design document. The game design document describes the game story through storyboards, animatic, gameplay design and rules, and sketches design elements such as characters and environments (Fullerton, 2008). The preproduction phase is supposed to be creative, and the creative flow should not be interrupted during this phase. In this project, we have used theory from Darsøe (2001) and Gee (2007) to make the student groups as creative as possible. This phase is a chaotic brainstorming process, which later is summed up in the game design document. According to Callele et al (2005), the game design document is a creative work written by the game designer or the game designer team, which in this project are the teacher students.

The Production phase focus on creating the game that was designed in the Preproduction phase. In this phase traditional software development methods like iterative development effort, agile methods and/or prototyping is used to implement the ideas from the game design document (Ollila et al, 2008). Fullerton (2008) recommends agile development that strives to make the development process more adaptive and people-centric in this phase of the project.

An alternative way to develop an initial concept and a game design document for a pervasive game can be to use a Concurrent Design Process (CCD). In a CCD-process we gather the stakeholders in the game and let them brainstorm and write a game concept, and a game development project plan. This process uses creative and structured meetings, with the involved stakeholders working on the concept from different competence viewpoints.

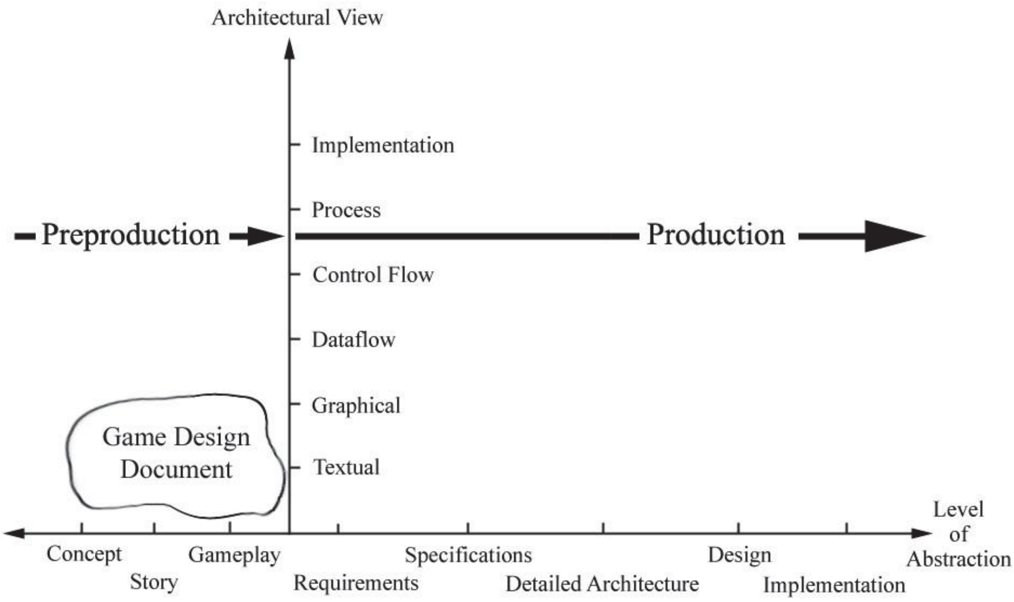

Figure 1: Video game development (Callele et al, 2005)

Pervasive games are a broad category of games that is mainly played in the real world but includes clues, hints, texts, pictures, videos or even small digital games from the digital world. The user must use or solve these digital hints/clues or games to solve the complete game. Example of pervasive games can be Alternate Reality Games where players cooperate to share and understand information presented on the Internet or other digital media, or Urban Adventure Games where the mail goal is to experience a town in a new way. Using pervasive games for learning, they provide new and different social settings and challenges that let the children play and have fun while learning. The game becomes a community of practice (Lave and Wenger, 1991) where the children work towards the same goal - to win the game. During the game playing the need to study theory pops naturally, but the children see it as something they need to do to solve the game instead of 'boring' theoretical school studies. We believe pervasive games used in this way can both enhance motivation to learn and provide alternate ways for children to study.

1.1 Research question

How can student groups with complementary competence develop an improved concept for pervasive games for learning in primary and secondary schools?

2. Research method

We categorize this research project as a Case Study based on a dual concept development process to make pervasive games for learning. In a case study the researcher asks questions, makes assumptions and decides on the scope of the task (Askheim and Grennes, 2008). The assumptions in this project are that students with different skills and academic backgrounds can design and create concepts for pervasive games for learning in traditional elementary school classes. Collaborative process methods like Concurrent Design (CCD) are known to increase the quality of the game concept, and are used throughout this project. The scope of the research is based on four different student assignments done at NTUC and HUC.

The researchers and the informants' work together to design the game, solve the challenges and implement the game ideas. This kind of research is classified as ethnographical design (Askheim and Grennes, 2008).

2.1 Data collection at NTUC

At NTUC, the goal of the first part of the project was developing different concepts for pervasive games for learning in schools though a group task in the course Game Based Learning for teachers (10 ECTS) in the fall of 2013. We divided the 29 students into six groups. The main competence of the participants in this course was pedagogy and practical teaching. The assignment was to develop a concept for a pervasive game to use in their schools. The students published the concept documents of the pervasive games as a portfolio in a Virtual

Learning Environment (LMS). One of the teachers was also the researcher in the project, and worked close to the process. In this way, the research process could be viewed as an action research project.

The second part took place in the fall of 2014. This time the student's assignments were to improve upon a selected game developed by the students in the first part of the project. The main goals for this assignment were to suggest new and improved ICT-related design and suggest digital development tools and support for the chosen pervasive game concept.

These 22 students were third year bachelor students of the Games and Edutainment track at NTUC and had relevant competence as game developers. We introduced the assignment with an introduction to the CCD-process and the chosen pervasive game concept for further development. We divided the students in four heterogeneous groups and each group had 4-6 students with different roles. The CCD-session was limited to a one and a half hour session. Each group wrote a Google document together to document the process.

2.2 Data collection at HUC

In HUC there is a fairly competent game track consisting of 3 bachelors with 250 students; Bachelor in Animation, Bachelor in Arts and Design and Bachelor in Game Technology and Simulation. In 2012 we let these students develop a pervasive game in a class on System Thinking, and later take it into 5^{th} and 7^{th} class elementary school to let the children play the game during a school day. The project was highly successful, the children named it "the best school day ever". The project is documented thoroughly in (Nordby et al, 2014; Nordby et al, 2015).

The project was completed in 2014 at the 4^{th} year of the teacher education, and was carried out in the same way as the teacher project in NTUC. The teacher students proved able to make fairly good pervasive games, though on a lower technical level than the game students. As in NTUC, the teacher education students had to be taught the basics for game development before they made the games.

In HUC the data collection methods were equal to the ones in NTUC. In addition, the students here wrote blogs, made web pages and a Facebook forum to document their development process. They also wrote research reports at the end of the project.

As stated above the pervasive game was aimed at elementary school children, more specific 5^{th} and 7^{th} grade, and was built on competency aims from 4-7^{th} grade of Norwegian elementary school. The main focus was to teach the children Sustainability and System Thinking. The students also developed three digital games as part of the overall pervasive game. The first digital game was about the refugee situation in the world. In this game we wanted the children to feel the despair of being a refugee, and the unfairness in not getting asylum when they had survived and arrived at a destination country. The second game was about the human consumption and the ecosystem. Here we wanted to teach the children how to prevent and repair the pollution of earth, water and air. The third game was about the soil health and pesticides, all seen from an earthworm perspective. The complete pervasive game played out within the children's school area. After the children had played the game, they got a 25-page diary to sum up and organized their learning experience. Lastly, they did a one-hour system thinking session to discover how things they learned about in the game were connected. The college students made web pages, blogs, and reports from the project that served as documentation for the project.

3. Related theoretical aspects

The theoretical aspects that underpin this paper are mainly related to learning theory and gamification, the use of concurrent design for develop pervasive game concepts and theory on how to maintain creativity during the initial pre-project brainstorming.

3.1 Learning theory in pervasive gamification

Pervasive game development contains creative and immersive processes similar in many ways to game playing. It is about making gams out of non-gaming environments, which these days often are labeled as Gamification. Gamification is a broad categorization that has many definitions, for example "using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning and solve problems" (The learning Circus Blog, 2012). As such, game development shares the same basic learning theory fundament as Gamification does. Werback (2015) points out how gamification is rooted in cognitive psychology and frequently uses points, badges and leaderboards to create intrinsic and extrinsic motivation. Gamification is more than this though; it can be seen as a community of practice where the students can work together towards a common goal in a problem based way, while learning events pops up naturally. At each learning event, players are motivated to solve the task, and rarely find it odd to study the theory to solve the task at hand. A community of practice is about situated learning (Leave and Wegner, 1991), and the fact that the students "make a pervasive game" instead of "learning how to make a pervasive game" is experiential learning (Kolb, 1983). The students are "learning by doing" (Dewey, 1916) while the learning events pops up naturally "just in time" (Gee, 2007).

3.2 Concurrent design in pervasive game development

Concurrent design is an approach to computer supported cooperative processes where several stakeholders actively participate in a design project. Strand and Staupe (2010) and Strand et al (2012) have described the main principles for concurrent e-learning design and empirically tested the method for developing formal e-learning in higher educational institutions. The prescriptive framework of concurrent e-learning design contains five sessions: Situation analysis, Possibilities study, Solution selection, Solution design and Design completion and Implementation planning. In the planned sessions, they point out four main areas: Pedagogical strategies and learning activities, Knowledge and learning outcomes, Technical delivery and Business. Further, the process involves stakeholders like customer representatives, institution staff, service providers, prospective users, project leader and different experts and decision makers. A facilitator runs the process sessions and follows up the work between the sessions. The process is supported by shared documents and collaborating software. In all sessions, they use a specific CCD-location where the participants can collaborate and share conflicts issues, discuss alternative solutions and take immediate decisions.

Similar CCD processes was design as results of the Interreg Sweden-Norway project Distributed Concurrent Design, 2011 – 2014. This project funded at specific CCD-location at NTUC. A pilot study took place in 2014, and the project was to develop an application for support to deliver broadband connection to two rural areas. This work was organized as a CCD-process with three sessions at the CCD-location at NTUC. The participants were from the administration of Steinkjer municipality and the stakeholders from the two rural areas and the software developers. The participants collaborated through a number of Shared Google Documents.

Figure 2: The CCD-location at NTUC with the facilitator place at the meeting table and 12 PC's for the participations along the walls

A CCD process has some common characteristics:

- The process must involve participants with relevant competence, and the participants must have decision-making authority.
- Initially the facilitator and/or project leader have made necessary session plans and support documents.
- Collaborative digital tools for the work must support the process in sessions and between the sessions.
- The CCD sessions should take place in a dedicated CCD room designed for efficient collaboration, and a facilitator should lead the sessions.

3.3 Inspiration and theory for the preproduction phase

We have labeled the creative process that is carried out *before* the actual pervasive game development process the preproduction in our documentation. In the preproduction, the students work in groups to brainstorm their game ideas. Darsø (2001) labels this process the Preject and describes how this process is different from the rest of the project in that it should be a process balancing between chaos and structure to make the process creative. She discusses how assignment of roles to participants in such processes (the innovation gardener, jester, conceptualizer and challenger) can help maintain the creative potential in the group, and that creative groups should be put together as heterogeneous as possible, and ideally contain 6-10 people.

4. Results and discussion

In this section, we present some results from the project and discuss some of the advantages and disadvantages of the different concepts of making pervasive games for learning purposes in schools.

4.1 Pervasive game concepts developed by the teachers

The first part of the pilot study was traditional group work sessions. Each group develop a pervasive game concept where they describe the game goals and rules, the main learning outcome, secondary learning goal during the game, and how the participants will play the game. They also make sketches of the game environments, characters and storyboard, and since it is a pervasive game, what kind of actors is needed and what roles they will have in the real part of the game. Each game should last a school day.

Some of the games were tested in school environments and proved to be very popular. In NTUC two of the games were reviewed in a local newspaper:

- *Keiser Resir* is an alternative reality games for K4-5. The game topic was recycling of waste, and the goal was to save “the environmental flag” inspecting the recycling practice in the school, and show that waste to make new products. The last task in this game was to make Christmas decorations using old light bulbs.
- The *Liberation of the language teacher* is a treasure hunt game. The purpose of the game is to work with different assignments in “Nynorsk” (a secondary variant of the Norwegian language) through digital tools, and to win the race to free their kidnapped teacher.

One advantage of pervasive games is that we do not need special equipment; the teachers could usually use what the school already owned. The game can also be played inside the school or in the existing campus without many modifications. Since the teachers are familiar with the school curriculum, they can easily make the game elements and rules so they achieve the same learning from the game. Pervasive games are also relatively fast and easy to make and the teachers can make the assignments, clues and applications themselves. To make the game the teachers can us available digital pictures, letters, diary’s, digital maps, videos, email, smartphones, tablets, laptops, Smartboards, QR-codes/scanner and GPS, walki-talkies etc. Teachers and students (when they were available, such as in HUC) also did the acting and prepared all the scenery and locations before the game started. All in all the teachers can do it all themselves; from design to implementation. Most children also have smartphones these days, which are computers in their own right, and can be used for all kind of tasks such as digital game playing, goggling, visiting forums or groups etc. A good idea could be to group the children so that at least one smartphone is an asset of each group.

We found that some of the games made by the teachers did not use all available digital tools to vary the game play, possibly because the teachers are not yet “digital natives” and a bit scared of the digital domain. This will change though when new generations get old enough to be teachers. Some of the games developed could benefit from more advanced use of ICT, software, apps and digital content in the gameplay.

4.2 CCD Session for improving a pervasive game concept

We found that some of the games created by the teachers had potential for a larger audience, and could benefit from more advanced technology to provide better immersion. We chose the urban adventure game concept of *“The mystery of Agatha Hanssen”* for further development. The goal of this game was to introduce the players to life in Namsos town during the Second World War, and give the players knowledge about the war history of Namsos. Namsos was bombed and burned down at the beginning of the war. The local museum in Namsos is the base of the game, and the museum curator introduces the game presenting some document from Agatha

Hanssen. The document reveals that she has hidden something at five different places in the town to avoid the Germans, and the players will have to find those things to solve the mystery. The players are divided into five groups, and each group is given an IPad and a web page for reporting results. During a school day, the players have to explore and discover what happens to Agatha Hanssen at those five locations in Namsos reading her letters, her diary and using city maps and hints from the game.

To improve this game we did a single CCD session involving student groups from the game track. The students were first introduced to the original game concept of *Agatha Hanssen* and the concept of CCD-processes. The students took on different roles for the CCD session such as Game designers, Producer, Programmers, Visual artists, Quality Assurance, Work estimation/economy etc. The teacher was the facilitator in this process. Each group collaborates through their own Google document. The duration of each session was one and a half hour.

The four groups (G1 - G4) presented and analyzed ideas for demand and workload for further development of the game. After four equal sessions, the students found several ideas to improve the game concept of *Agatha Hanssen*. The main ideas are listed below and marked with the group number.

- A broken letter could be puzzled and made readable at the IPad (G1). Parts of a letter could be collected at different places and lead the students to find the solution of the story and game (G1).
- Use QR-codes to read and collect information at some of the locations and QR-codes could give clues for the game (G1).
- Introduce a digital game board at the IPad. Using GPS-tracking, the game board allowed the teachers and other players to view the locations of gamers (G1).
- Use an IPad to collect points, puzzle pieces or give historical facts on Namsos (G1).
- Use the geocaching web site with information and GPS coordinates at historical places in Namsos (G1).
- The game could contain videos where you meet *Agatha Hanssen* in different locations and situations, and other places presented in the game.
- Present the story of *Agatha Hanssen* in a mobile app. The GPS coordinates controls which part of the story the player received at the IPad (G4).
- An interactive AR-app could show pictures and 3D models. One location at the game is a crashed plane from the Second World War, and presenting a 3D-model of the plane at the IPad will give new game possibilities and learning outcome. 3D models presenting the town before and after the bombing attack could improve the game. Further, the AR-app presents the church, the bridge and the English Channel in Namsos and several other historical places could improve the gameplay (G2 and G4).
- Augment Reality and video sequences could show *Agatha Hanssen* and the pilot of the bomber (G3).
- Develop a scoreboard at the IPad. One idea was to make a pizza-layout where the player gets a slice for each task completed and real pizza when the players have finished the game (G3). Another idea was a puzzle of the life of *Agatha Hanssen*. The player get one puzzle piece for each task they complete (G4).
- Introduce a step counter for the scoreboard (G4).
- In a digital map could give relevant locations for the game, and be linked to a scoreboard for the player. Link the scoreboard to a web portal where the player posts their result continually (G4).

In addition to this, some of the groups had ideas for how to improve the gameplay in general. Some of these suggestions will give better gameplay; give better learning outcome and deeper immersion into the game. When selecting features like the list presented above, time, costs and effort to implement them must also be considered.

4.3 Discussion of the use of a CCD process for a pervasive game concept

The case study shows how it is possible to develop a pervasive game using game designers without game development background. Teacher students with basic digital competence and skills did make playable pervasive games, and some of them related the concept to a relevant and popular game in their school. We found that one of the biggest challenges was the integration of relevant ICT tools and software for a more digitalized gameplay.

Students in a program on gaming and entertainment have the digital competence and skills necessary to make pervasive games that use all kinds of digital tools, but often lack competence to incorporate good learning and proper learning goals.

Collaboration projects though have proven to be very beneficial, and are possible both within the curriculum of NTUC and HUC.

4.4 A tentative CCD-process for development of a pervasive game concept

Based on the earlier concepts of concurrent design processes, we suggest a similar CCD process after the creative brainstorming part in the Preproduction (Callele et al, 2005). In this process, stakeholders and experts from relevant areas will have to participate:

- Teacher who want to use pervasive games to teach specific topics or educational goals. Our pilot study includes topics and local events from the Second World War history and the geolocations for those events.
- Game Designer who knows how to design pervasive games on the specific topic.
- Each game element has to be implemented by programmers, visual artists, animators, game designers, storytellers and others with relevant competence for the project.
- Financial specialists will have to estimate costs of each game element and the overall cost for the project.
- Project leaders and a facilitator for the CCD-process are also necessary.

The outcome of the CCD-process is a relevant game design document and a project plan for developing the game.

So far, we have defined three CCD-sessions for the development of a game concept. Figure 3 shows more details of the content of this process. Those three CCD-sessions have different purpose:

- Define the game concept. In this first CCD-session, the core topic, storyline and game concept is designed.
- Creating digital game elements. The purpose of this session is to create possible digital game elements, hints, resources and tools of the game concept.
- Implement the project plan. In this CCD-session, the aim is to write the content for the game design document, and make a project plan for the total game.

This concept can be realized as a project in higher education with participation from different programs like Teacher education and Game development studies.

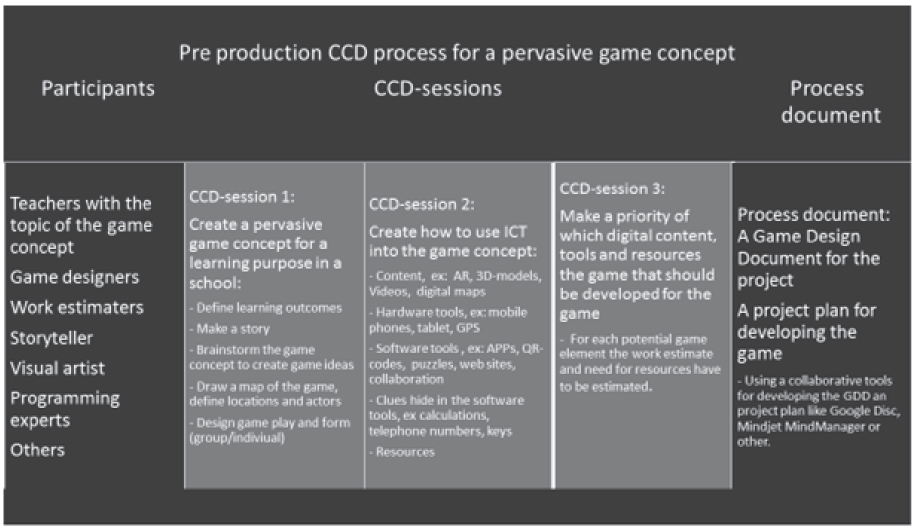

Figure 3: A preproduction CCD process for developing a pervasive game concept

5. Conclusion

We have discussed how game track and teacher students have developed pervasive games for learning and pointed out the importance of using participants with complementary background. Teacher students have their strength in pedagogics and experience with teaching, and know how to use the campus as playground and how to utilize existing technology in schools. Involving game track students can enhance the gameplay and immersive nature of the games and these students also knows existing and new technologies and how to utilize those in games. Further, game track students can hold different roles like game designer, storyteller, visual artist, and programming experts and do project plans and estimate workload for improvements. Next, we have investigated the working process in the Preproduction phase with the goal of developing a game design document and a more advanced pervasive game. In our four cases, we have investigated different process tools like brain storming work, group work and a more structured concurrent design process. From the case study using a limited CCD process with students in the game program track, the students described 14 suggestions of improvement for a pervasive game concept. This is a good starting point for working out a new game design document and a project plan for developing a new and better version of the pervasive game. In figure 2, we suggest a new model for the Preproduction process using a concurrent design process. A CCD process gives a better structure of the work using working sessions and collaborative tools for the work. Further, a CCD process involves students with different background and competence, and the students get specific roles and perspectives like teacher/user, game designers, storyteller, programming expert, project leader and others. The aim for the work is to develop a game design document and a project plan for developing the game.

5.1 Further research

We have to investigate how the new model using concurrent design for the preproduction phase works in a real project that will involve students from the game and entertainment track in cooperation with teacher students or real teachers in a school.

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Teachers' Experiences Using KODU as a Teaching Tool

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Abstract: Digital games have become a part of the cultural and social reality in the Western world today, largely shaping the lives of those who have open access to them, children and young people in particular. In recent years digital games have been gathering acknowledgement as teaching facilitating tools and resources. This means that games are increasingly being applied in educational situations and within various educational contexts, which again requires that teachers not only understand both the potential and the limitations of digital game based learning – but also the fundamental coding logic that is the bases for all digital gaming, as well as numerous other things in our daily lives. In February 2013, 3 University Colleges in Norway started a cooperation project, creating a new University college course, titled "Game-based learning" (n. "Spillbasert læring"). The goal was to prepare teachers at different levels of the education system to employ digital games in their various forms, as learning tools. Programming is an important part of game-based learning and in this project the Microsoft programming tool Kodu Game Lab was utilized. The course was first tested out at The Nord-Trøndelag University College (HiNT) in the autumn semester of 2013. This paper analyses the reflections of the teachers who participated in the first digital game-based learning course on how they experienced the employment of the Kodu coding tool in the classroom. Inspired by domestication theory and engagement theory, this paper presents the experiences of the teachers when they got to learn to teach basic coding skills to their pupils. We identify several themes that came up in their reflections, such as first impressions, reflections about digital natives and digital immigrants, the concepts of *learning to use* versus *using to learn*, the status of the teacher, prejudice, attitude change and IT-challenges.

Keywords: coding for children, game programming, games, Kodu, DGBL

1. Introduction

In recent years, digital games have been gathering acknowledgement as teaching tools, increasingly being applied in educational situations and contexts. This requires that teachers both understand the potentials and limitations of digital game based learning, DGBL, as well as the fundamental logic that it is based on; the coding.

Kodu is a simple programming tool that enables children to create digital games. It has been presented as a door-opener into the world of computer programming and coding for both children and beginners. Kodu has a uncomplicated, visual approach and is easy to master, even at the earliest stages of grammar school. It teaches logical thinking, setting the ground for more advanced programming (Lær Kidsa Koding!, 2015; Kodugamelab.com, 2015). Kodu engages pupils, generates creativity and can be used to train storytelling as well as programming. "Students were involved with problem solving, game making processes as solutions and the creation, design and deconstruction of multimedia texts" (Fowler, 2012).

The research question of this paper is: How do teachers experience the use of KODU as a teaching tool in the classroom? The paper first presents theory on the topic, and then describes the methods used in the study. In the following sections findings are presented, analysed and discussed, before reaching a conclusion.

2. Coding for learning

DGBL refers to learning that is aided or facilitated by digital games. The idea is that through engaging in playing a digital game, students of all ages should be able to learn as much - or possibly even more than they would through other methods of learning (Prensky, 2001a; Van Eck, 2006). DGBL is gradually becoming an accepted teaching approach, although until quite recently the educational components of digital games were ignored by many educators, who often focused on their negative effects on players and saw them of little relevance to the educational context (Squire, 2003). Over 90% of Norwegian children today play digital games in their free time (Medietilsynet, 2014). This generation is often referred to as "digital natives", that is; children and the younger generations that have grown up with digital technologies as part of their everyday life (Gee, 2012; Prensky, 2001b). The assumption is that the digital natives have better digital skills than other groups and that using digital media is "natural" to them.

At the same time, only a small group of the digital natives have a basic understanding and knowledge of the logic, the structures and the mechanics of digital games. "It is as if they can 'read' but not 'write'" (Resnick et al. 2009, p. 62). Coding literacy is a 21st century skill, becoming increasingly vital in our modern society (Prensky, 2008; Fowler, 2012, Gee, 2012). Those who are not born natives to the digital world have been dubbed "digital immigrants". Although they can learn to live with, adapt to and employ digital technologies, "they always retain, to some degree, their 'accent', that is, their foot in the past" (Prensky, 2001b, p. 2).

"A GBL approach for learning programming should provide opportunities for active learning, trial and error paradigm rather than simply supporting students through conceptual knowledge" (Kazimoglu, Kiernan, Bacon & MacKinnon, 2011, p. 41). Teaching children and young learners to code is not only about teaching them a basic skill, but also a good way to teach them systematic thinking, as well as problem-solving skills. Moreover, there are several indications that programming a game results in more and deeper learning than playing a game (Prensky, 2001a; Gee, 2003; Fowler, 2012; Vos, Meijden & Denessen, 2011; Li et al., 2013).

The task of programming may seem overwhelming to many young students – and their teachers. Software developers have produced simple, object-oriented programming languages, that teach coding to children and other inexperienced programmers, in structured but simple ways (Fowler, 2012; Prensky, 2001a; Vos, Meijden & Denessen, 2011). In order to facilitate easy access for the students, enabling them to learn on their own, making their own trial and error, it is important that programming tools of this sort be open and free of charge (Kazimoglu, Kiernan, Bacon & MacKinnon, 2011).

An educational programming language is a designed primarily as a learning instrument. Logo, Scratch and Kodu are good, yet different, examples of such. Logo and Scratch are used in a browser (Turtleacademy.com, 2015; Scratch.mit.edu, 2015), while Kodu requires a desktop installation (Kodugamelab.com, 2015). Logo is command based, created in 1967 (El.media.mit.edu, 2015), best known for the controlling of a "turtle robot" who makes line graphics on the screen, but also supports more advanced programming using e.g. conditional loops and custom procedures. Scratch is a visual (drag-and-drop), block-based programming language, introduced in 2003 (Maloney et al., 2004). Kodu Game Lab from Microsoft, introduced in 2009, is a tile-based visual programming tool enabling users to create and play video games. In edit mode you make the terrain, place game objects (e.g. characters, trees, paths, sounds), and program game objects using the entirely event driven Kodu programming language (Fowler, Fristce & MacLauren, 2012).

Game coding may be employed as a teaching method for different goals and purposes. An obvious purpose is to teach students – and teachers – to code. However, having students code a learning game, related to their subjects, is a method that has multiple benefits; not only do the students learn coding, but they learn the subject they are teaching through the game, and in best case scenarios the end product may be used in DGBL for other students (Prensky 2008; Osman & Bakarl, 2013). Coding games facilitates differentiated learning, enabling teachers to meet the different needs of their students (Fowler, 2012; Tomlinson, 2014). Game coding further fosters creativity, creative thinking and storytelling (Resnick et al., 2009; Fowler, 2012; Ke, 2014). Game coding is a motivating approach that helps in making schools engaging learning environments (Prensky, 2008) and offers innumerous opportunities for innovative teaching and meaningful learning (Resnick et al., 2009; Li et al., 2013).

In spite of numerous positive aspects of coding in school, research has revealed some challenges. Preconceived negative ideas about games and programming, on behalf of leaders, teachers, parents and even the pupils themselves, may complicate successful game coding implementation in school (Steinkuehler, 2010; Osman & Bakar, 2013). Technical challenges and problems with software may also reduce the learning experience and lead to dissatisfaction (Fowler, 2012; Bingimlas, 2009). Despite the alleged digital fluency of the digital natives a study can result in frustration on behalf of young learners, when the technological aspects of game coding prove to be difficult to them (Ke, 2014).

To help us make sense of our data we will make use of two theories; domestication theory and engagement theory. Domestication studies have explored how ICTs find a place in our lives (Haddon, 2011), and the domestication framework is also interesting when it comes to game development platforms in educational settings. The domestication framework considers the process shaping the adoption and use of ICTs, including questions like 'What do the technologies and services mean to people?', 'How do people experience ICTs?' and 'What roles can the technologies come to play in people's lives?' (Haddon, 2011). We find the domestication approach relevant to reflect on the process when coding becomes a part of a curriculum.

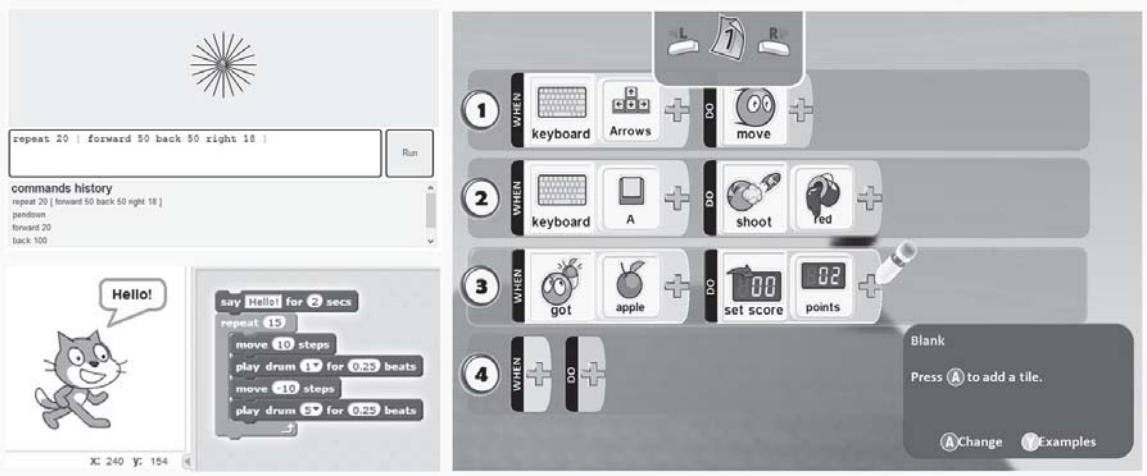

Figure 1: Screenshots from Logo, Scratch and Kudo

By engaged learning, we mean that all student activities involve active cognitive processes such as creating, problem-solving, reasoning, decision-making, and evaluation. In addition, students are intrinsically motivated to learn due to the meaningful nature of the learning environment and activities (Kearsley & Shneiderman, 1998, p. 20).

Engagement theory acknowledges the unique learning properties of ICT and claims that the ways in which technology engages can be difficult to achieve through other means. The three core elements of engagement theory are relating, creating and donating (Kearsley & Shneiderman, 1998; Marshall, 2007). When put into the context of coding in school, the relating process is when the learners put the task into context. This involves a set of important skills, such as communication, collaboration, planning and management. The creating part is obvious in coding, as it refers to developing their game. Finally, donating refers to the contribution of the product (the game). e.g.to other learners, in different contexts.

3. Methods

In the autumn of 2013 Nord-Trøndelag University tested out a new course, titled "Digital Game-based learning". The course was part of distance education studies, and included two 2-days gatherings. Game coding with Kodu was utilized in the first gathering.

This paper analyses the reflections of the teachers who participated in the first digital game-based learning course, on Kodu. It is important to note that the course was not planned for research purposes. After the course ended, the rich data provided during the course, was analysed. The data consists of 24 reflection notes made by the teachers / teacher students who participated in the course, 23 "one-minute-papers" (short forms carried out after each gathering) and 4 cases described in project reports, where teachers had designed (and partly tested) learning activities using Kodu.

When using data of this sort, it is important to note that texts and assignments that students know will be evaluated as a part of their personal grade at the end of the course, are bound to be somewhat "biased". What they say in a text that they know will count as a part of their final grade, may thus be somewhat influenced by their hope for a good grade. This must be considered with regard to the project reports and the reflection notes. The "one-minute-papers" were anonymous and have, as such, the potential to reflect upon another side of the truth.

4. Findings

4.1 First impressions

In the one-minute-papers participants answered questions like what they thought was the most meaningful concept, what was difficult and unclear, and what did they like least and best. 8 (out of 23) students named Kodu or coding as the most meaningful topics, 7 using positive or neutral comments like "Kodu - a whole new thing to me, a very relevant tool". Coding was mentioned 9 times as the most difficult/unclear, however, 4 of the answers were not entirely critical "Kodu was challenging, not unclear". Kodu only came up twice as the topic they liked least, while 6 students specifically mentioned coding as the topic they liked best. To summarize, it seems that most of the teachers had a positive first impression of Kodu.

4.2 "Learn to use" versus "use to learn"

One of the project reports describes the use of Kodu in an optional subject called "Media and information". There were 12 students (8th graders), and their ICT knowledge varied. The assignment was to develop a game each. The stronger students helped the weaker students. The teacher demonstrated simple building and coding, while the students worked on computers. The teacher then showed them how to find instructional videos on Kodu coding. The students worked for 3 hours on the game-making assignment, learning how to code and develop a game. This is an example of a "learn to use"-session. Several teachers emphasized the importance of learning to code, which illustrates the concept "learn to use". One teacher wrote in his reflection note:

"For assignment 2 I was to get to know game programming better, through Kodu. This was really fun and challenging! I have never tried anything like this before and I have not understood the importance of youth learning more about how data programs are structured. I think coding will become an inevitable part of school in a few years time."

Another case describes two teachers using Kodu for a group of 6 upper secondary school students with special needs. The interdisciplinary curriculum had learning goals in science, mathematics and "production". The lesson was carried out during three hours and the students worked in pairs. The main pedagogical approach was discovery, with some teacher-led activities. Afterwards, the students reflected upon their learning process, and the teachers assessed the students through observations, their products (the games) and a questionnaire. In this case Kodu was used to teach more than just coding. Other teachers suggested using Kodu to learn several other subjects, e.g. matrix, text production, collaborative tasks about problem solving and conflict solving.

4.3 Digital natives and digital immigrants

The teachers found Kodu motivating for their digitally native students. "Two of the boys in the group actively play "Minecraft", and they were overwhelmed by excitement when I told them that we were going to learn how to code digital games". In case 2 (described above) the teachers experienced that the students were motivated to learn other subjects using Kodu as a tool. "Here we have 'sneaked in' knowledge". Another teacher said: "These lessons clearly provide added value to school-tired students, as they learn in an alternative way that motivates them".

Many of the teachers initially had low confidence with regard to digital games. "I have never really played digital games myself. That might be the reason for why I have not used digital games much in my teaching practice." The students, however, are often portrayed as "digital natives". "I teach a generation, who in contrast to me, has grown up with digital technology from a very young age. The digital language is almost a part of their mother tongue, - they use it to communicate with each other, they express themselves digitally and use it to understand the world. Many of my students, despite their young age, often play digital games and are very interested with the world of digital games. They roleplay the most popular games. They write from the world of games, they use game-names and stories from the games."

Another teacher says the students learned to develop a Kodu-game quicker than she. "'It is just like Minecraft'. I was simply impressed to see how solution-focused they were, how visually appealing their worlds were, and how fast they understood what to do. This was very motivating for me, and I am considering using KODU in a large class later." A teacher who performed a small survey in the class found that a majority of the students found coding easy. Yet several teachers felt insecure, “I have to practice more on my own - create more games in Kodu, before I move onto working together with the students”.

As digital immigrants, some teachers felt that Kodu helped their digital self-confidence. “For me, and probably many other teachers, a course like this provides self-confidence and courage to try using digital games within an educational context. In many schools, digital games will be considered negative. A teacher, who introduces digital games, needs support from her environment and the school leaders, ascertaining that this is something we want to try out and gather experience from”.

4.4 The status of the teacher

Some teachers described how they felt that it boosted their status among the students when they coded in the classroom. It made them feel “up to date”. Their Kodu skills show the students that they master a technology that the students are interested in. It is experienced as an investment in team building and a good class environment. “I realize that as a teacher, I have to log into their world, I have to learn about their gameworld to create good relationships - show them that I care about their interests.”

Two teachers who tested Kodu in their class, concluded that “We feel that we succeeded in connecting the learning to the students’ pastime interests. For us as teachers it feels good to know that we have conducted a learning process, which the students enjoyed.” They further reflect that, “maybe it is positive that we - the teachers – were ‘forced to’ get updated on the world of the youth”.

4.5 Prejudice and attitude change

Several teachers confessed previous negative attitudes towards digital games. “Personally, I have … been negative to the use of social media and digital games in education”. The teachers also claimed colleagues, leaders and IT departments had reservations towards digital games. One teacher reveals that the principal had agreed to buy 25 licences of MinecraftEdu, demanding, in return, that the teacher developed educational DGBL concepts for the other teachers. The teacher wondered if the principal would have had the same demands if the purchase had been text books. Several teachers also inform about extra efforts to persuade their IT departments to install Kodu.

The teachers describe a gradually decreasing prejudice, throughout the course. “I felt sick the first time I had to try Kodu, and the learning curve was quite steep. Who would believe that two months later I planned and carried out a learning activity with Kodu, and whether you believe it or not, I am actually eager.” Another teacher summarizes the experience by, “During this autumn I have totally changed my views towards digital games”. Instead of using games as supplements, they now consciously used digital games as learning tools. “Using Kodu was crucial to my attitude change. I have gone from seeing problems to seeing solutions, from seeing an indoor activity and poor learning outcomes to seeing productivity and innovation”.

4.6 IT-challenges

One of the challenges the teachers report are technical issues. Several teachers describe the frustration of having to “fight” for the software they would like to use in the classroom. “What limits the use of a game like Kodu, is that it is necessary to install the software on school computers. “I have not got approval from the IT department of the municipality. They laughed at me ... The way ahead for using Kodu in my teaching, seems uncertain right now”.

Two teachers use the term “persuade” with regard to the IT department, illustrating that simply informing about what kind of software you need is not enough, arguing and justifying was required as well. “The problem, at the moment, is that the IT department does not want to install Kodu on the computers. I hope this will be settled using persuasion.”

5. Discussion

The teachers’ experiences show that coding offers unique learning properties and is truly an engaging method of learning. The domestication process however, is threatened by obstacles, such as prejudice and IT-challenges.

The teachers domesticate coding in different pedagogical contexts. Some teachers use Kodu as a code learning tool, while others domesticate Kodu as a tool to learn math, science, text production etc. “Learn to use” and “use to learn” were two main concepts from the governmental plan of ICT in Norwegian schools already in 1996 (KUF, 1995). Østenrud, Larsen & Erstad (1999) describe “learn to use” as “how to master ICT as a tool and instrument”, while “use to learn” is described as how to use ICT learning other subjects. A coding software like KODU is ideal for learning both computer skills and other subjects.

The NMC Horizon reports apply a delphi process for bringing experts to a consensus viewpoint around the impact of emerging technologies on teaching, learning, or creative inquiry in the near future. “The expert panel identified nine key trends, nine significant challenges, and 12 technologies to watch” (The New Media Consortium, 2015). The Scandinavian report differs from the other two (The NMC Horizon Report 2014 K-12 Edition and the NMC Horizon Report 2014 European Schools Edition), with regard to DGBL and perceived time-to-adoption horizons.

“The Scandinavian panel sees games and gamification as a near-term horizon topic, while the other two panels believe it is at least two to three years away from mainstream adoption. ... Scandinavian schools are emphasising the idea of play in the classroom as a means of learning and increasing student engagement (The New Media Consortium, 2015 p. 4).”

Our study shows that teachers’ attitudes easily change through experiences with DGBL, and that teachers have clear visions on implementation of DBGL in their classrooms. Furthermore, the experiences of the teachers show the core elements of engagement theory in practice. Teachers describe how students collaborate and learn from when developing a game in Kodu. The nature of the Kodu game design platform provides teachers and students with a tool where it is natural to work project-based, with focus on collaborative exploration and experimentation in a process of planning, designing, developing and evaluating. We see that the students enjoy creating games and their reflections show that intrinsic motivation makes it easy for them to accept and domesticate Kodu as a learning tool. We see that the pupils easily relate to Kodu and are both willing and capable of planning and putting it into context as a relevant learning tool. The donation part of the engagement theory may not be entirely applicable to our sample, as our data comes from teachers who had just been introduced to coding teaching tools for the first time and how – or to what extent – the pupils products may or may not be used for future teaching or experiences is not reflected in their notes. We do, however, note that there is a difference in use when it comes to valuing the process or the product of the students’ work. Some of the teacher described assessing the students’ products (games), while others were more concerned with the process itself, and some students had self-evaluations on their learning process in Kodu.

6. Conclusions

Drawing on domestication theory and engagement theory, the paper given a brief insight into the possibilities of using Kodu for learning. Through data collected via one-minute-papers, reflection notes and project reports from the course “Digital game-based learning” we have shed a light on teachers’ experiences with Kodu.

Seen in the light of engagement theory, the teachers find Kodu a motivating tool and a platform that encourages project-based learning with planning, designing, developing and evaluating digital games. The teachers domesticated the coding software in varying shapes. Some domesticated it in a “learn to use” way, and others in a “use to learn” way. Kodu is domesticated into different subjects, within a wide age group. The domestication is also involves an attitude change among teachers, the status of the teacher among the students and students’ motivation to learn. The domestication process is, however, threatened by obstacles, such as prejudice and IT-challenges.

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Using Game Elements to Make Studying More Engaging

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Abstract: A lot of potential exists for systems that enhance learner engagement using game elements. In particular, elements that support the activity of learning, that are designed around learning but that are distinct from the subject matter a learner is studying. This paper describes such a system, the particular support focussed on is goal setting - setting custom learning goals, independent of the course being undertaken, and tracking progress on these goals in a game like way. Students' approaches to study have been classified by a number of different inventories, perhaps the most popular is Biggs' Study Process Questionnaire (SPQ) which divides students into one of three categories - Utilising (studying no more than is necessary), Internalising (where studying is an intrinsically motivating activity), and Achieving (getting grades for their own sake). Is it possible to facilitate the state of flow, to enable more students to experience study as an intrinsically motivating activity more often? This work explores the design of a system with the goal of answering this question. This system has been trialled with a class of final year BSc computing students in order to assist them with the activity of studying for exams. The aim of the trial was to determine the degree to which the game-like system succeeded in making studying for exams more engaging. This paper describes the design of the system, and the design and results of the trial.

Keywords: game elements, studying, flow, intrinsic motivation

1. Introduction

Students study in many different ways. These approaches have been classified by a number of different inventories, such as SPQ (Study Process Questionnaire), LASSI (Learning and Study Strategies Inventory), and ASI (Approaches to Studying Inventory) (Entwistle and McCune, 2004). Perhaps the most popular such inventory is Biggs' Study Process Questionnaire (SPQ), which classifies students into one of three categories:

- *Utilising* (focussed on obtaining grades and only studying what is necessary, the validity of the material is not questioned);
- *Internalising* (studying is an intrinsically motivating activity, syllabus free - the student sets himself goals);
- *Achieving* (getting the best grades for their own sake, characterised by systematic approach to study e.g. study schedules (Biggs, 1979))

The main study strategy inventories (see for an overview of each (Entwistle and McCune, 2004) each contain an element corresponding to the intrinsic motivation such as in the *Internalising* category above. It is this intrinsic motivation that is highly desirable in learning and learning related activities. "When people are intrinsically motivated, they experience interest and enjoyment, they feel competent and self-determining, they perceive the locus of causality for their behavior to be internal, and in some instances they experience *flow*" (Deci and Ryan, 1985).

Flow is an immensely enjoyable mental state that is characterised by a "complete immersion in what one is doing" (Csikszentmihalyi, 2000). Indeed, it is so enjoyable that people invest considerable amounts of time and money "for the sheer sake of doing it" (Csikszentmihalyi, 1990). That is, people do an activity for itself "and not for the usual rewards of everyday life, like a paycheck or a promotion" (Csikszentmihalyi, 2000), it is intrinsically motivating.

Is it possible to facilitate this state of flow, to enable more students to experience study as an intrinsically motivating activity more often? This work explores the design of a system with the goal of answering this question. The general approach used was Human Centred Design, which is an iterative process with four main stages: observation, ideation, prototyping, testing (Norman, 2013). For the testing phase, a study was conducted to determine the degree to which it succeeds, and to gather feedback to inform the next iteration of the system.

This paper is structured as follows: it begins with a description of related work, then describes the key stages of the design process, the study, a discussion of the findings, and finally conclusions and an outline of future work.

2. Related work

The use of game elements in non-game systems have been used to increase interaction, engagement, and intrinsic motivation, across activities including commerce, education, health, industrial work and intra-organizational systems (Hamari, Koivisto, and Sarsa, 2014). Although this approach has been frequently applied to education and learning, the majority of these applications have focussed on applying game elements directly to the learning activities (Hamari, Koivisto, and Sarsa, 2014). To date the use of game-elements and gamification to enhance the activities surrounding learning in higher education, such as studying and goal setting, has been limited. However, where these techniques are being applied they have shown promising results, such as in the area of new student induction in higher education. The work of (Fitz-Walter, Tjondronegoro, and Wyeth, 2013) looked at using game elements to motivate and engage new students in college induction. This approach tied achievements to real world events that would benefit the students including: geographic orientation, social interaction (meeting new friends), attendance at college events, and awareness of available services and facilities. Similar work by (Smith and Baker, 2011) investigated the use of narratives and puzzles to encourage exploration and learning about library facilities. To further incentivise participation, prize draws and extra course credit were used as additional real world and extrinsic motivators. Despite these successful examples there is limited research being undertaken in this area, even though the activities surrounding learning at higher education, and not just ability, are crucial to success (Tinto, 2006).

As with the use of all game-elements, care must be taken in the selection of appropriate elements that are relevant and well integrated in the experience. One approach to ensure this is to adopt a human-centred approach to design that can avoid meaningless or even harmful gamification (Nicholson, 2012). Of particular note is the risk of using of game-elements to promote competition, even though it is not universally motivating (Domínguez et al., 2013).

3. Design

The general approach used was Human Centred Design, which is an iterative process with four main stages: observation, ideation, prototyping, testing (Norman, 2013). Observation involves making observations on the target population, with the aim of understanding their true needs - a limited set of these needs is selected and results in the problem statement; Ideation entails generating ideas that might lead to potential solutions; prototyping involves quickly building potential solutions; testing requires users to use the prototypes “as nearly as possible to the way they would use them” and observing and gathering data to ensure it meets the needs of the users (Norman, 2013). Key elements from each of the stages are described below.

3.1 Observation

Observation for this iteration was done largely from informal ethnographic study and from literature. In terms of the specific studying context of the cohort of students upon which the study is based, students were observed in the activity of studying which consisted largely of reading PowerPoint notes from computer screens. The students also used past exam papers to focus their reading. However, none of the students used any aids to set their study goals or to track their progress.

When it comes to studying, students can be strategic in their use of time and disregard content that they think has a low chance of being assessed. This point is made in a number of places, for example,(Gibbs, 2004) and in (Miller and Parlett, 1974, p.60):

> *“I am positive there is an examination game. You don’t learn certain facts, for instance, you don’t take the whole course, you go and look at the examination papers and you say ‘looks as though there have been four questions on a certain theme this year, last year the professor said that the examination would be much the same as before’, so you excise a good bit of the course immediately …”*

3.2 Ideation

The key ideas of those generated and gathered were:

The three key conditions of flow

There are three key conditions for flow: first, a person must engage in a challenging task that requires skills and he must believe his skills match the challenges of the task; second, the task must have clear goals - if the goal is clear the person will know, at any moment, whether or not he has reached it; third, the task must provide immediate feedback – that is, information letting the person know how well he's doing (Csikszentmihalyi, Abuhamdeh, and Nakamura, 2005). Note that the task can supply the feedback (as with the tennis player who can see after each shot if the ball went where it was supposed to) or the person can have a standard internalised in his mind, and he can tell how well his actions measure up (as with the poet who reads the last line he wrote and knows if it is right) (Csikszentmihalyi, 1999).

Game elements

many successful systems use of game elements for changing behaviour, for example Health Month (http://healthmonth.com) and stackoverflow.com. This suggests they are a promising approach to follow.

The previous system we developed, for facilitating learners to focus on mastery using learning outcomes representing in a treemap (O Broin and Power, 2014).

Other design inspirations: iTunes interface.

3.3 Prototypes

Several prototypes were generated, and two were selected by the researchers using the following criteria: intuitiveness, ease of learning, and simplicity. The first prototype used the treemap view similar to what was used in a previous iteration of this system (see Figure 1). The other using star ratings (see Figure 2), selected for its ease of learning, to get a baseline with a standard element before exploring the effects of less standard game elements in future iterations. Before starting to study, students can create custom goals, consisting of a set of learning outcomes. These goals map out what will be accomplished in a particular study session, or for a longer term goal such as a class test or final exam (all the learning outcomes for one or more of the topics in the course). The prototypes were developed using JavaScript/CSS/HTML on the client side and using Python with Tornado (Tornado, N.D) and MySQL on the server side and WebSockets and AJAX for communication.

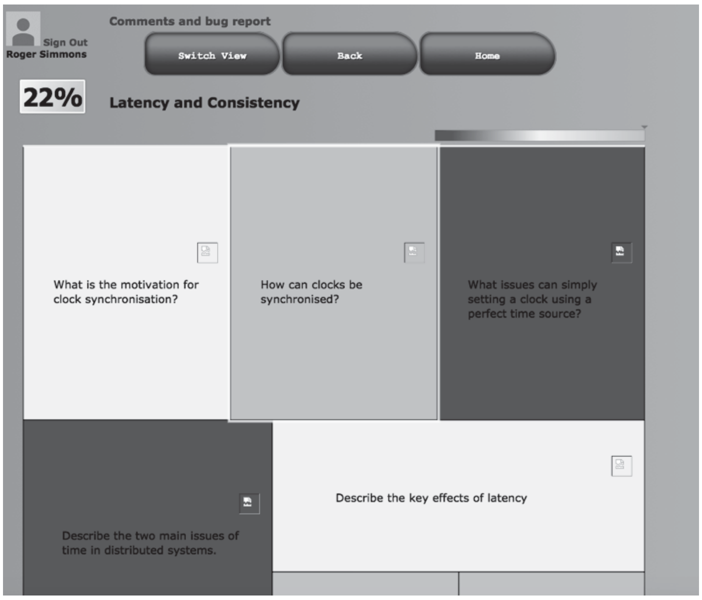

Figure 1: The system showing the treemap element, depicting the learning outcomes for the topic "Latency and Consistency", and the colour indicates the degree of mastery (red indicates major problems with the learning outcome and green indicates mastery). The overall progress on the goal displayed at top left (22%)

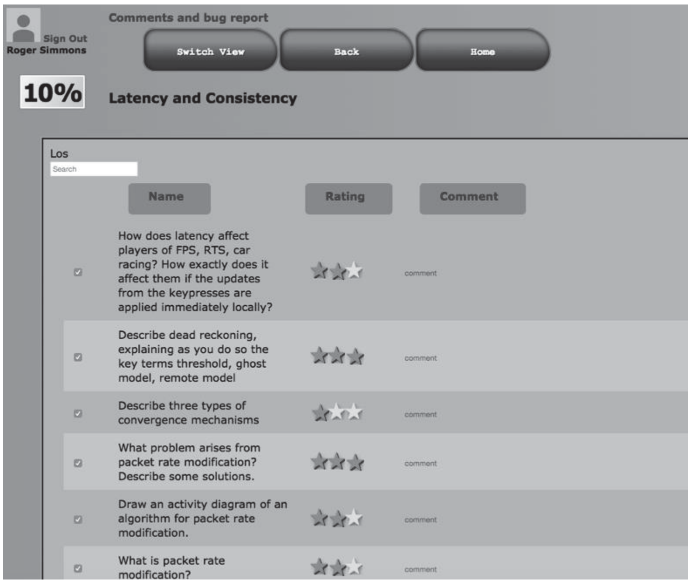

Figure 2: The system showing star list element – users can see the topic (Latency and Consistency), the learning outcomes (under name) and their perceived level of mastery of the learning outcome (0 stars – haven't looked at the learning outcome, 1 star major issues with the learning outcome, 2 star minor issues with the learning outcome and 3 stars, with the learning outcome is mastered)

3.4 Testing

Four usability sessions took place in which two cohorts of students were given one of the prototypes and asked to perform a set of tasks (setting up an account, navigating to a section, rating a learning outcome, and creating a goal). The students were observed carrying out the tasks. Some minor issues arose, and these were remedied before deploying the system for the study.

4. Study

The goal of the study was to learn more about facilitating more students to experience study as an intrinsically motivating activity. The hypothesis is that different people prefer different game elements, and some prefer different game elements for different contexts/purposes.

4.1 Method

A class of final year Computing students (23) was split into two groups, each was assigned to use one of the prototypes for one class test, then the other for another class test. After this, they were free to use whichever version they wished to use.

A condensed version of the USE questionnaire (Lund, 2001) was used to measure usefulness, ease of use, ease of learning, and satisfaction and the instrument's scales go from 1 (strongly disagree) to 5 (strongly agree). In addition, the questionnaire specifically addressed the participants' preference of the different systems. User activity was measured from the system to enable the participants' responses relating to certain areas to be corroborated – for example, a participant says she prefers the star element, and then the activity measured shows that she uses the star element four times as often as the treemap element.

4.2 Findings

A summary of the results of the survey of the 23 students who completed the course are shown in Figure 3.

As with the previous similar system, high levels of usability, usefulness and satisfaction were recorded, as shown in Figure 4.

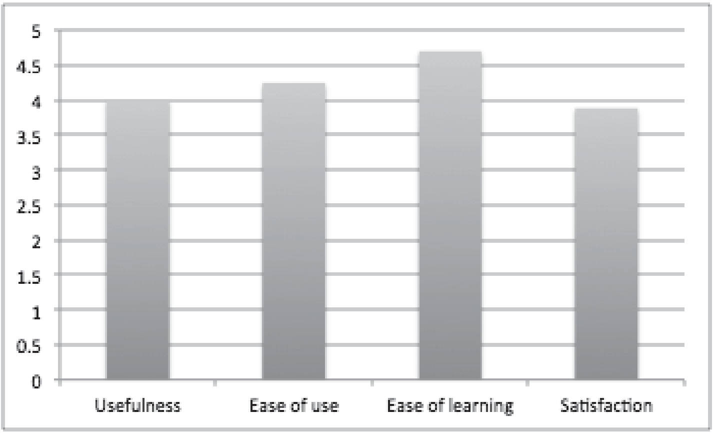

Figure 3: Both systems (the system with treemap element and the system with the star list element) demonstrated high usefulness, ease of use, ease of learning and satisfaction

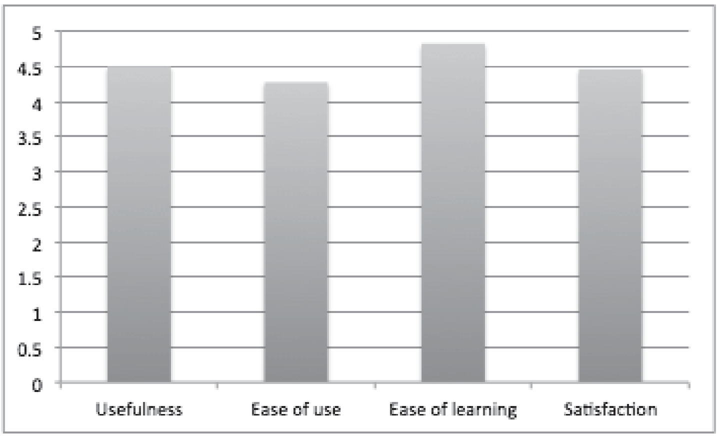

Figure 4: The results from a previous iteration of the system (2013) comparable (only slightly higher than the current one)

The preference of participants was for the star list element (65%), 25% preferred the tree map element, and 10 % did not prefer one over the other (see Figure 5).

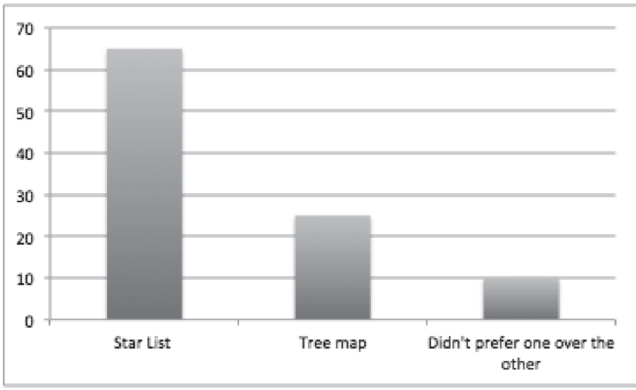

Figure 5: Comparison between the star list element and the treemap element in terms of user preference (percentage of users).

It was found that self-reporting corroborated with actual user activity in terms of preference for one element over the other. This can be seen by comparing user preference (Figure 5) and user activity (Figure 6) when students were free to choose either element.

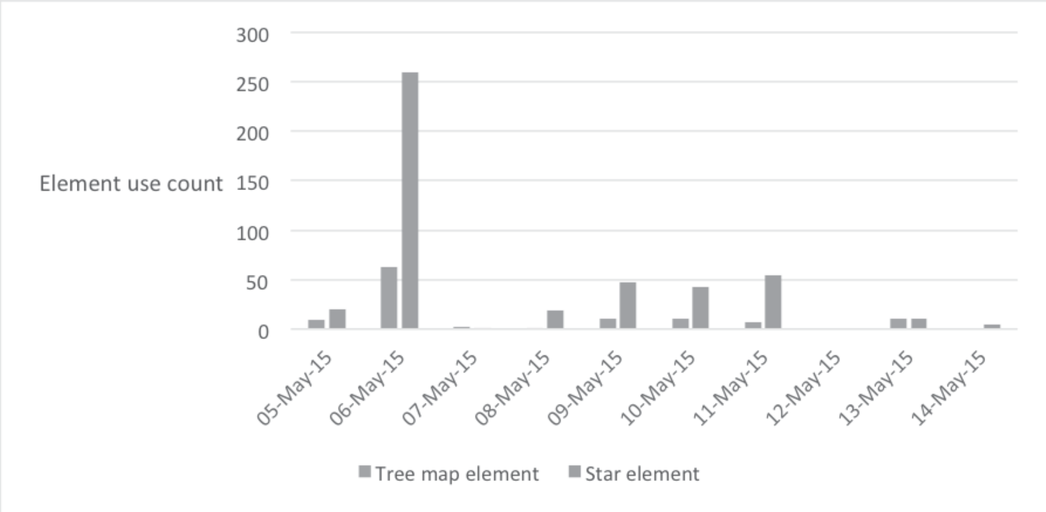

Figure 6: User activity compared between the two systems – the star list (orange) vs tree map; this is actual use, which corroborates with self report

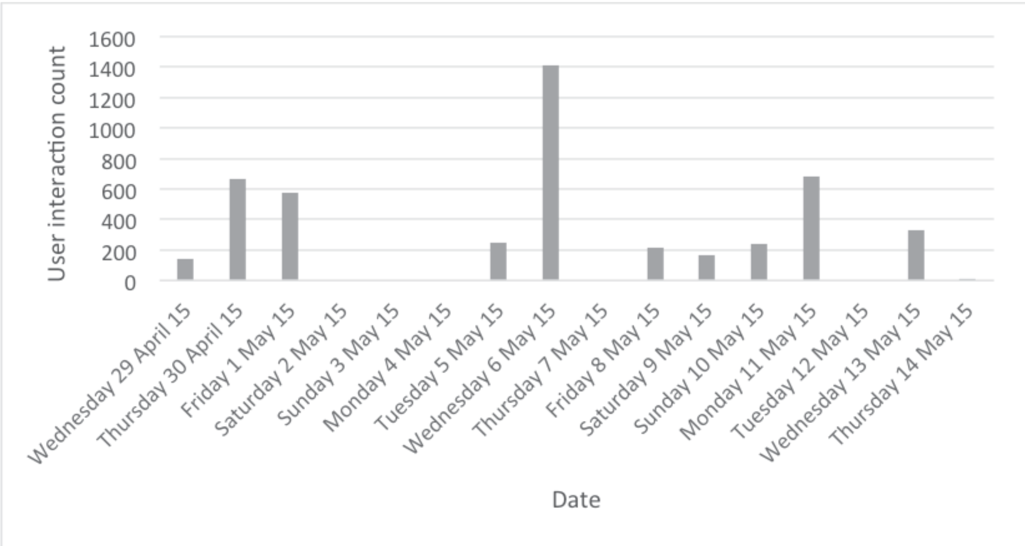

Figure 7: Overall use – this indicates the level of activity of the users – the spikes of highest activity are before exams

As an indicator of the usefulness of the system, it was found that usage activity dramatically increased right before exams (see, for example, 6/5/2015 in Figure 7).

Several issues were identified with the treemap element. Firstly, it used multiple clicks to rate (one click to change a learning outcome rating to red (meaning major issues), another to yellow (minor issues) and another click to change it to green (no issues/learning outcome is mastered). This was compared unfavourably to the 1 click system of the star list. Other issues mentioned were that there was no search ("if I want to view my comments I have to manually search for them. It's a major issue that prevented me from using the tree-map view for revision."), comments were more difficult to add and read than in star list, and the lack of order of the learning outcomes in treemap ("I really disliked how the information wasn't easily readable due to not being ordered.")

Several of the participants mentioned employed the different elements for different purposes, for example:

> *"I found the treemap view better for initial study planning. When I first opened up a list of LOs, I found it easier and much quicker to scroll through all of them in the treemap and mark off what I already knew."*

"after filling in the list view i found the map useful for an overview of questions you dont know well which i found very useful for revision as i didn't have to search the lists to find questions it was all there in the tree map"

"I used both for different purposes. It's easier to find a question using the list and more satisfying to update it using the tree map."

A particularly interesting insight from a participant stressed the effect the treemap had:

"The Red/Yellow/Green colours also stand out more (and have more effect) than the stars in the list view. Seeing a LO in a red tile impressed upon me that I should revise it far more than seeing it with one plain star beside it."

Two of the participants mentioned uncertainty as to whether they had mastered a learning outcome, and suggested:

"i would also put in a system that you can submit answers that can be looked over by a lecture and decide if the answer is correct or not so the user knows for definite if they are going in the right direction"

Some students in the Utilising category found the system beneficial:

"it helped me to pick certain things to study instead of trying cover everything. "

And some found other benefits which had not been envisaged:

"good tool to use for feedback to the lecturer as you can ask questions you might be embarrassed to in class the lecture gets direct feedback of topics to cover for revision."

5. Discussion

The issue of users having to click an excessive number of times could be readily addressed by overlaying star ratings on each rectangle of the treemap, thus enabling rating with one click as can be achieved in the star list. Searching could be addressed also (by automatically scrolling to the relevant element). It is not clear how the issues relating to adding and reading comments and the lack of order can be addressed. It may be that they can't be, and that the elements work better for different purposes.

Beyond this, some deeper issues emerged. One is that the system in its current form is syllabus bound (Biggs, 1979). This can be addressed by enabling participants to add their own learning outcomes (and indeed a number of participants requested this feature). This would facilitate Biggs' Internalising.

In addressing uncertainty over mastering a learning outcome, the suggestion of referring answers to a lecturer would be one possibility. Another method might be to provide an objective measure in addition, such as a multiple choice quiz game tailored to different player types.

Another drawback is that there is significant work required by staff to use this system - in particular, the complete list of learning outcomes for each topic in a course needs to be identified and set down in a spreadsheet.

Despite the challenges encountered there was support for the hypothesis that preferences for game elements vary between individuals and between contexts of use. It is anticipated that this may prove to be a useful heuristic in further iterations of this system.

6. Conclusion and future work

This work described the latest iteration of a system designed to enable more students to experience study as an intrinsically motivating activity more often. While it has demonstrated success in terms of usefulness and usability among its users, there is potential for more game elements that align with user preferences and context. The most interesting outcome of this work in terms of future iterations was how different elements were not preferred over competing elements, but that both alternatives were used by some users for different purposes. A drawback that was noted is the significant effort required by staff to use this system for a particular course – mainly importing the complete list of learning outcomes for each topic. We aim to address this issue in future iterations of the system.

There is potential for many other game elements that go beyond just representing progression. Examples of game elements to explore include: a map for progress e.g. Crayon Physics (www.crayonphysics.com), adding sessions and end of session animations like GamiCAD (Autodesk Research, N.D.), adding a more juicy interface including sounds and particle effects (Whitkin, 2014). Also, the issue of the uncertainty of rating learning outcomes could potentially be addressed by complementing the subjective measurement of learning outcomes with an objective measure. For example, a quiz game with different mechanics tailored to different player types. A second approach is to explore integrating rubrics for handling more complex learning outcomes that cannot be easily measured by the present system. What is essential in these explorations is that the game elements added do not encourage surface learning (Marton and Säljö, 1976) e.g. Utilising and Achieving - but rather *Internalising*.

Acknowledgements

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Using Gamification to Motivate Smoking Cessation

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Abstract: Smoking cessation represents the single most important step that smokers can take to enhance the length and quality of their lives. In this paper we present a case study of the commercial web-based *freeFromNicotine* course, which provides a game-based approach to smoking cessation. Participants follow a 50 day long program tailored to their individual situation. Gamification is used both as a control mechanism to measure how well the participants follow the course and to motivate the participants to complete according to plan. An important motivational element included in the design is the opportunity for participants to compete against themselves and others based on game points awarded for completing goals and assignments. Research within GBL has shown that in Pervasive Educational Games, competition has a positive impact on player participation. However, offering individually tailored courses while providing all users the opportunities to participate in the overall competition on equal terms is a challenge. This paper presents the gamification approach adapted in the course and how this affected and was perceived by the course participants. *freeFromNicotine* proved to be successful in getting people to quit smoking, but was not a commercial success due to marketing problems. However, participants who managed to quit smoking after completing the course mentioned competition as an important motivational factor and we can conclude that the gamification and design principles proved successful and can be deployed in other types of learning games.

Keywords: gamification, pervasive games, game based learning, health games

1. Introduction

Smoking is one of the leading causes of preventable death globally and compared to the rest of the world, the WHO European Region has one of the highest proportions of deaths attributable to tobacco (WHO 2015). The estimated costs of smoking for EU/EFTA countries is € 97.700.000.000, of which the direct costs of smoking are €49.83 billion, and the indirect costs of smoking are €47.87 billion (SFP 2015). Hence there is much to gain by getting people to quit smoking. A Norwegian survey shows that 72% of those who smoke want to quit (Helsedirektoratet 2014), however only about 4% - 7% are able to quit smoking without medicines or other help (ACS 2014).

freeFromNicotine (FFN) was developed by the companies Active Software ANS (discontinued) and MT Master ANS (now Sincos Software AS) as an attemp to adress this problem by providing a web based “quit-smoking-course” using gamification as an important design element. FFN was available online in the period 2006-2012 (but with less activity in the last part of the period). Huotari and Hamari (Huotari and Hamari 2012) define gamification as “*A process of enhancing a service with affordances for gameful experiences in order to support user’s overall value creation*”. This definition focuses on user perspective and gamification used to increase participation and motivation. A more technical perspective that focuses on game mechanics and game concepts is provided by (Deterding, Dixon et al. 2011) who define gamification as “*The use of game design elements in non-game context*”.

Being addicted to smoking cigarettes is a pervasive habit, hence designing a smoking cessation course as a pervasive game is a reasonable strategy. We define FFN as a pervasive game according the following technologically independent definition (Pløhn 2014): “*A pervasive game is a game that is pervasive relative to the player´s everyday life*”. On the basis of this definition a pervasive game must, for the whole duration of the game, be both temporally and spatially pervasive relative to the player’s everyday life. Given these characteristics, pervasive games may enable a pervasive property to learning (Pløhn 2014).

2. Related work

Gamification has been used in many different types of environments and for different reasons such as education, pervasive health care, e-commerce, human resource management and many more (Meder, Plumbaum et al. 2013). Studies have provided empirical evidence that including game design elements increases participation (Thom, Millen et al. 2012) and enjoyment (Herzig, Strahringe et al. 2012). Research has shown that games can be used to increase participation and motivation of the students in higher education (Wang and Wu 2009) and competition has been identified as a motivational factor in learning games (Pløhn and Aalberg 2014). *freeFromNicotine* encompasses both gamification and competition as key design principles.

Pervasive gaming is a research area that is becoming increasingly popular and some research on the use of pervasive games to support learning has been done. Pervasive games such as *HiNTHunt* (Pløhn and Aalberg 2013), *Tough Road* (Ejsing-Duun, Hanghøj et al. 2013), *Nuclear Mayhem* (Pløhn 2013), and *The Search for the professor* (Spikol, Pettersson et al. 2009) have proven that pervasive games can be used to motivate students and support learning.

3. freeFromNicotine (FFN)

freeFromNicotine (FFN) is a web-based smokers' cessation program designed as a 50 day long real time pervasive learning game. The course program is tailored to the individual participants' specific situation based on information collected from a questionnaire that each of the participants must fill in on the first day of the course.

Quitting smoking is a difficult process and FFN is designed to help the participants' through the whole of this process. During the course the participants are led through three different phases distributed over the 50-day course program as follows:

- Habit breaking – 25 days (day 1 - 25)
- Quitting smoking - 21 days (day 26 - 46)
- Follow-up care - 4 days (day 47 - 50)

Smoking consists mainly of habits that smokers must break. This is the focus in the first phase where participants are motivated to quit and learn techniques to resist the craving to smoke. Breaking habits is difficult and this phase lasts for 25 days. Towards the last part of this phase the participants have to reduce their smoking so that by the start of phase 2 they are free of smoking. In the second phase the participants are no longer allowed to smoke and this phase is mostly about how to handle the craving for smoking and how to remain smoke free. Even though physical dependence on nicotine disappears after 3-7 days, the psychological dependence lasts for 15-20 days (which is why this phase lasts for 21 days). The third and last phase is the shortest, but is just as important. Statistics show that a large number of those who manage to quit smoking will take up the habit again within the first year and the final phase deals with how to establish attitudes and create a plan for the next 12 months.

FFN is a real time course meaning the course once it is started will continue regardless of whether the participants log in or not. The nature of smoking cessation makes it important for users to participate fully in a defined period of time. However, if a participant for some reason is unable to log into the course for a period of a few days, all tasks and assignments are made available as "Uncompleted daily exercises" (Figure 1) and the participants will have the opportunity to complete them when they log in.

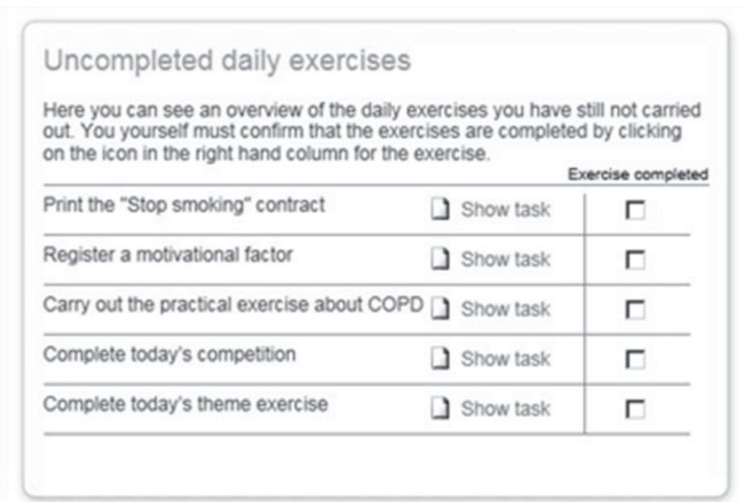

Figure 1: Screenshot from FFN showing uncompleted daily exercises (assignments)

Gamification is an important design feature of FFN and components such as game points, levels and a high score list are key elements. There are three levels corresponding to the phases of the course described above. The user is not allowed to advance from one level to the next unless certain requirements are fulfilled within given time limits. Upon failure to accomplish this, the user will be prompted to restart the course (equivalent to "die" in a game and restart from a given point). During the course, if there is a risk that this situation may occur, the user will receive warnings and will be advised on how to avoid failing. To monitor user activity and provide feedback, FFN uses the total game points achieved so far and compares this to the ideal sum a user could have achieved at this stage (Figure 2).

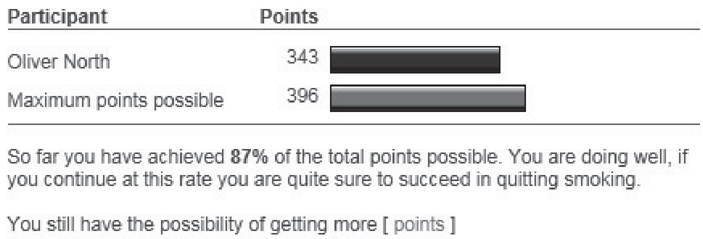

Figure 2: Screenshot from FFN showing the participants game points compared to maximum points possible

Each day of the course the participants can achieve a given sum of points, hence game points is a good indicator for degree of participation. The percentage of total possible points achieved is used to evaluate progress and participation (Figure 2) and give feedback and follow-up the user. For example a low percentage over time may indicate lack of motivation of a user that is less likely to quit smoking at this stage in life and the user should be informed that he/she should restart at a later time when they are more motivated.

FFN uses game points to enable competition both between individuals and groups. Single users can compete against themselves by trying to achieve the highest score possible at all stages (Figure 2) and for those who participate as part of a group, the scores are presented so that the group members compete against each other.

The course program in FFN is built up as a series of different type of assignments that the user has to complete (Figure 3). Some typical examples of tasks are:

- Print out and sign a "Quit Smoking" contract with friends and family
- Different types of practical exercises (one example is the practical exercise about chronic obstructive pulmonary disease COPD ((NIH 2015) where the users has to breathe through a straw for ten minutes)
- Theme days where the user learn more about various topics and must answer questions to prove that they have understood the topic
- Writing about different topics in the forum
- Register and working with their motivational factors (a recurring task throughout the course)
- Competition on knowledge of smoking-related questions (quiz)

4. Design principles for freefromnicotine

There are different principles and considerations behind the design of FFN and the assignments that are given in the duration of the course, and in this paper we will focus on the gamification aspects, which are based on the following principles:

1. FFN shall be designed as a game where users have the opportunity to compete against themselves or others in completing the course (competition)
2. The course can be tailored to individual users smoking habits and life situation
3. The course program shall be composed of various theoretical and practical tasks (assignments) that the user must perform each day of the course
4. All users should have the possibility to participate in the overall competition on equal terms
5. It shall be possible to earn points (compete) each day of the course
6. It must be easy to add and remove tasks

Requirement 2, 3 and 6 led to a module based framework with a core "skeleton" to which modules are attached. The framework includes the overall behaviour such as which modules each user shall perform on each given day of the course, user data, game points, leader boards, dependencies between the modules, the progress of the course, the user interface etc. The modules are the individual assignments users have to perform and modules are connected through a common interface. This module based design is illustrated in Figure 3.

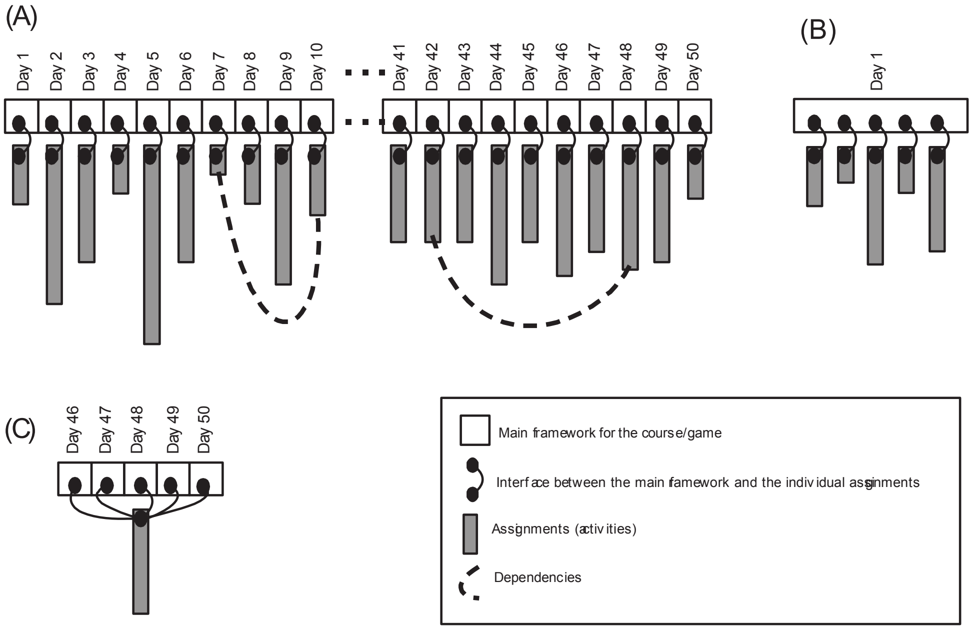

Figure 3: FFN framework and modules (module based design)

In Figure 3A we see the 50 day long period with assignments for each day of the course. The dotted line illustrates dependencies between assignments for example the assignment given on day 10 is depended on how the user completed the assignment given on day 7. Figure 3B illustrates that there can be many different assignments given on the same day and Figure 3C illustrates that the same assignment can be given on many different days of the course. The different length on the assignments illustrates that some are small and easy to complete and others require more effort.

The course program can be tailored to each user (requirement 2) by selecting assignments from a pool when generating personal course programs. Assignments can be chosen according to information each user register about smoking habits and specific life situation. Each tailored course program consists of only a selection of the assignments available in the pool.

To provide the possibility for all users to participate in the overall competition on equal terms (requirement 4) the principle of *core assignments* and *individual assignments* was introduced (see Figure 4). C*ore assignments* have to be performed by all participants and generate game points (requirement 1) when completed. *Individual assignments* do not generate game points. This design enables users to compete on equal terms since all users have the *core assignments* as a part of their course (requirement 4). *Individual assignments* are given to users based on their smoking habits and personal life situation hence it is the *individual assignments* that are used to tailor the course to each users preference (requirement 2). To ensure that the users perform all assignments in their course and not only those that award game points, users are not told until after the assignments are completed how many game points (if any) this assignment generated. Any given day of the course may consist of at least one *core assignment* and zero or more *individual assignments* (req. 5).

Figure 4 illustrates how the course program from day 1 to day 50 is tailored to individual users A, B and C by a combination of *core assignments* (the grey areas) and *individual assignments* (the white areas) selected from a *pool.*

The fact that there is a "solid core" of scoring assignments (core assignments) also means that there is a fixed maximum score for each day of the course. This is used as a control mechanism to measure how well the user is conducting the course (Figure 2) as described in section 3. To motivate the user to participate in the course as it is designed, the highest score is given for *core assignments* completed the same day as they are given. A lower score is given for assignments completed a day after and even lower after two days. After more than two days the user will still have the opportunity to complete the task (Figure 1) but without being rewarded.

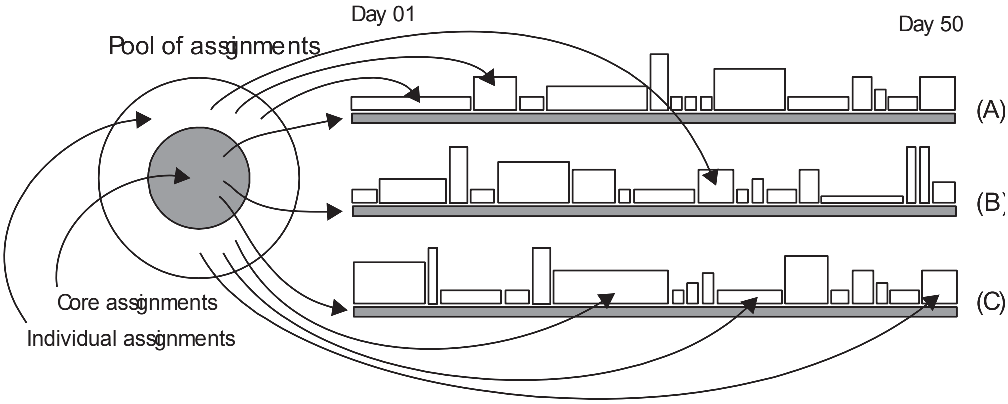

Figure 4: Pool of assignments and three individually tailored course programs

The diversity of assignments used also means that gamification can be applied to many types of normal everyday activities such as "*The user is from this day not allowed to smoke inside his/her home and must now go outside to smoke. The task of today is finding an outside spot where the user has to go to smoke and the apartment/house must be properly cleaned to remove all odours of smoke*". This assignment is a part of the *habit breaking phase* and is a game point awarding assignment. However, there is no means to automatically detect that this task is performed and the system relies on the user being honest when these assignment are marked as completed. The completion of other types of assignments such as "*writing in the FFN forum*" or "*writing in the users personal journal*", can be automatically detected and will contribute to the feeling of interaction and feedback.

5. Participants, methods and procedure

A total number of 255 persons registered as users. Out of these 74 had no activity and no user data generated. The final data is collected from the activity of the remaining 181 users (nDB = 181). This includes all types of activity logs from a variety of usage patterns ranging from the ones that only logged in once and performed none or few tasks to users that logged in every day and completed all tasks and assignments they were given. The collected data is gender and age neutral and depersonalized, but all data can be connected to the specific user that generated the data. The following types of data have been analysed:

- The user's personal journal (each day each user was given an assignment to write about their thoughts about quitting smoking, difficulties experienced, how they stay motivated, personal issues and whatever is on their mind)
- The discussion forum (the users were throughout the course given assignments to write and discuss different topics in the FFN forum, the postings were anonymous).
- General user activity (game points, how many times they have logged in, progress etc.)

Users finishing the course were asked to complete a questionnaire about their experience and suggestions for improvements. 14 users (nQ = 14) answered this voluntary questionnaire and even though such a small sample does not allow for statistically significant results, the analyses of responses of the open-ended questions may still provide an indication of the users' opinion about the competition aspect and the course in general.

In depth interviews were conducted with the person (ni = 1) who was in charge of the development and maintenance of the system. The interview mainly dealt with the design of the system, the effect of using gamification and lessons learned while the system was online and running.

6. Results and discussion

The company behind FFN experienced that the course was successful in order to support smoking cessation, but found it very difficult to generate a profit. Different business models were tried in order to make it commercially profitable and the product was advertised on the Internet, national TV and national radio. Licenses were sold to individuals and businesses that wanted their employees to quit smoking, many licenses where given away for free as advertisement and different price and payment models were tested. There are many possible reasons for the lack of commercial success. A main reason could be that people (at this time) expect products on the Internet to be free of charge.

When analysing the data we see that the users can be divided into three groups; the curious, the opportunist and the motivated. The curious are the ones that got a free license and logged in once or a few times just to see what it was all about maybe without establishing any dedication to actually follow the course. This was the largest user group. The second largest group are the opportunists, who also got a free licence, but registered and showed a higher level of commitment. However, they did not follow the course as intended; did not log in every day, and most of them failed to complete. The motivated is the smallest group and includes those that signed up, showed a high level of commitment by logging in every day and completed the tasks and assignments given throughout the whole period of the course. More than 50 percent of the participants in the motivated group managed to quit smoking and when analysing the achieved game score in this group we find that all of the users achieving 80% or more of the total game points managed to quit smoking. Knowing that less than one out of ten manage to quit smoking without help (ACS 2014), this indicates a success in assisting people to quit smoking.

The quotes in Table 1 are taken from the users' personal journals by analysing a total of 1242 diary entries from 181 users. The quotes are a representative sample of the quotes that expresses an opinion on the competition element of FFN.

Table 1: Quotes from the course participants personal journals on the topic of the competition element in FFN (the users are marked A – G for referral purposes only)

A	I shall win the internal competition at my workplace; I have a competitive instinct that no one can match.
B	I performed poorly in the competition today and I feel that that was a bit demotivating. I must work harder to stay on top in the competition. I become so angry when I answer wrongly on the quiz. I want to be on top! All of the answers were correct in today's quiz, hurray! Hooray, I didn't smoke and I got all of the points today.
C	I am getting more motivated when using FFN. I am a competitive person and I think this group pressure is helping me.
D	Amazing how competitive I am. I was actually disappointed when I answered wrong on two of the questions today, I did not like the thought that I wasn't on first place in the competition.
E	My wife is catching up with me. I want to win. I forgot to mark the tasks as completed yesterday! Lost a lot of points. Not good.
F	I am going to a party tomorrow and I must keep from smoking so I will get the extra points for not smoking.
G	I hate this assignment. If it was not for the game points I would not have done it.

The quotes in Table 2 are taken from the answers to the open-ended questions in the questionnaire that the users where given on day 50 of FFN (answering the questionnaire were voluntary). The quotes are a representative sample of the quotes that express an opinion on the competition element of FFN.

Table 2: Quotes from the questionnaire (Day 50) on the topic of the competition element in FFN (the users are marked H – N for referral purposes only)

H	.. I think that the assignments and the competition are motivating.
I	... I was surprised on how motivated I became by the questions, the daily tasks and the competition.
J	... It was fun to be able to get points; it immediately becomes fun to quit smoking.
K	... I think the assignments with the quiz where you had to search the Internet to find the answers where quite difficult and I was often unable to find the answer which was a bit demotivating for me. Otherwise I am very happy with the course.
L	... I liked the theme days and the competition. It was very motivating to be able to get as many points as possible.
M	I was very "triggered" by the competition to get the most points possible. Then you certainly could not smoke because you lost too many points. Obviously it was my own smoking cessation that was most important, but it became important for me to do well in the competition.
N	For me, the competition has been a huge motivational factor. I have worked diligently to be on top of the high score list. But at the same time, I was also demotivated the times that I was not able to stay on top of the list.

The quotes in Table 1 and 2 clearly illustrates that the competition was a high motivational factor. All of the quotes indicates that the competition/gaming element of FFN where perceived as important by the users and that they were motivated by the competition. Just as important as the positive quotes in Table 1 and Table 2 is the fact that we were unable to find any negative comment about the competition element in FFN in any of the data from the 181 users we analysed. The negative comments (user B, K and N) are not related to the use of gamification in FFN but that the competition element is so important for these users that they feel a bit demotivated when they are not doing as well in the competition as they would like.

One motivation for applying gamification in FFN was also to motivate the users to complete all of the assignments – even the assignments they do not like. The quote from User G in Table 1 clearly illustrates that the gamification element of FFN motivated this user to perform the assignments that he/she would otherwise not have done. Getting the most game points possible by completing the assignments the same day as they were given also seemed important to the users. This is illustrated by the quote from User E in Table 1 that is upset because he forgot to mark an assignment as completed the same day as it was performed and thereby lost a lot of game points.

The nature of the assignments in FFN where some assignments are automatically detected as completed and some assignments must be marked manually by the users as completed, is a design choice that provides possibilities for cheating. However, the analysis of the user data from the database does not indicate any sign of users trying to cheat. For example, the users are awarded with game points when they write in their personal journal, but FFN does not check whether the user has written a meaningful text. FFN just counts the number of characters and assign game point to the user when a specified number of characters are written. Hence users have the opportunity to cheat by entering a meaningless text phrase such as "asdfasdfasdf" to gain game points. However, the analysis of the personal journal notes in the database shows that all of the 1242 entries consist of meaningful texts. The same applies to the texts that the users where assigned to write in the FFN forum. From this we conclude that it does not appear that the users have applied cheating as a strategy to gain game points and we assume that the same honesty prevails when it comes to marking an assignment as completed and that very few (if any) will mark an assignment as completed if the task is not done.

The design choice of *core assignments* and *individual assignments* where it was only possible to gain game points by conducting the *core assignments* (to enable competition on equal terms and using the users total game score as a control mechanism), seems to be successful. As described in section 4, for most of the assignments the users do not know if they will receive game points or not until after the assignment is completed. None of the users have made any comments about not receiving game points when they have performed an *individual assignment* hence it seems like the principles of *core assignments* and *individual assignments* was accepted by the users.

7. Conclusion and future work

The main contribution presented in this paper is a gamified smoking cessation course based on a highly reusable design *core* and *individual assignments* design approach that enables both tailored courses for each individual user and competition on equal terms between the users.

The *freeFromNicotine* course demonstrates that a gamification approach where everyday activities are included in the game as assignments is a promising approach for including everyday type of activities in a game. Analyses of user data indicate that users are honest when they mark assignments as completed and that cheating is not applied as a strategy to gain game points. The possibility to rely on users registering correct information makes it easier to include everyday tasks in learning games.

Being a pervasive game that lasted for 50 days FFN could have provided facilities for supporting "in-game-awareness" which has proven to be an important property in order to increase player participation in pervasive games. Furthermore, FFN was conducted without a game story. Research has shown that the use of a game story may help to increase both player participation and player motivation (Pløhn, Louchart et al. 2014) and designing and applying a suitable game story to FFN may have helped to motivate the users.

The design principles used in FFN and presented here can easily be adapted and implemented in other types of learning games where there is a need to provide individually tailored courses while using gamification and competition as a motivational element.

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Teaching Business Intelligence With a Business Simulation Game

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Abstract: The term "*Business Intelligence*" (BI) has evolved from Management Information Systems to Decision Support Systems since the mid-1960s. Today, modern decision making methodologies and technologies are referred to under the term "Business Intelligence". The main purpose of this technology is to improve both the efficiency of users' decision making and the effectiveness of decisions. Decision support technology has been implemented and researched in industry and academia for more than half a century, however, challenges in teaching of this field still remain such as access to suitable data sets, finding interesting business cases, and providing realistic and meaningful experiences. Interestingly, the top rank of CIO global technological priorities is still *Business Intelligence and Business Analytics,* but the skills gap is significantly wide and negatively impacts on business. Moreover, it is not only the BI skills that are needed but also the 21st Century skills, such as, communication, social skills, creativity, critical thinking, problem solving, productivity, and risk taking – as suggested by the European Community to meet the requirements from the job market. This situation drives BI instructors to improve their teaching strategies or to have considered alternative methods to educate their students. *Business Simulation Games* are recognized as an effective educational method to enable students to learn how to make decisions and manage the business process in a modern enterprise, link abstract concepts to real world problems, and improve quantitative skills. Additionally, a *game* is a future technology trend that will be able to support developing new skills, because game characteristics can contribute and sustain 21st Century skills. Therefore, the "*BI Academy" (BIA)* project at the Stuttgart Media University in collaboration with the University of the West of Scotland has developed a business simulation game, called *BI game*. It is anticipated that using the BI game can help instructors to overcome the limitations and challenges in teaching BI, support students to improve their BI skills and 21st Century skills through the learning process, help students to get a better understanding of how to use BI tools to support decision making, and can leverage students' BI maturity level. This paper first presents the status of Business Intelligence in academia, the conceptual framework being used as the basis for game design, the technical framework supporting the game operation, and the organisational format of the BI game which provides a closed-loop learning environment. The paper then describes the preliminary results of students' self-assessment, which shows that most of the students assessed themselves as having quite good 21st Century skills but quite low BI skills. Finally, the paper will provide directions for future research.

Keywords: business intelligence, decision support systems, business simulation games, decision making, 21st century skills, BI maturity

1. Introduction

The term *Business Intelligence* (BI) has evolved from Management Information Systems to Decision Support Systems, which emerged during the mid-1960s (Power, 2007). Today, modern decision making methodologies and technologies are referred to under the term "Business Intelligence". This decision support technology is still an important research topic for both industry and academia (e.g., DSS2.0 Conference 2014). The main purpose of this technology is to improve both the efficiency of users' decision making as well as the effectiveness of decisions (Shim et al, 2002). Recently, a Gartner survey (Gartner, 2013) reported that *Business Intelligence and Business Analytics* have been in the top rank of CIO global technological priorities for several years – 2009, 2012, and 2013. However, the skills gap in this field is still significantly wide according to 60% of 2,053 CIOs of 36 industries across 41 countries. This skills gap has a negative impact on business.

Even though decision support technology has been implemented and researched in industry and academia for more than half a century, challenges in teaching this discipline still remain. Based on a survey from the BI Congress in 2009, 2010, and 2012 regarding the status of BI in academia, there were several significant challenges in teaching BI, for instance, access to data sets, finding suitable cases, and providing realistic and meaningful experiences (Wixom et al, 2014). In addition, the labour market needs more new skills and more new ways of learning (Redecker et al, 2011). Thus, it is not only BI skills that are required for the next-generation BI workforce (Wixom et al, 2010), but also 21st Century skills, such as, communication, collaboration, social skills, creativity, critical thinking, problem solving, productivity, risk taking, and sense of initiative and entrepreneurship – as suggested by the European Community as soft skills that are required to meet the requirements from the job market. This situation forces BI instructors to improve their teaching strategies or to consider alternative methods to educate students; for example, teaching BI with puzzle-based concept (Presthus and Bygstad, 2012), proposing a pedagogical design and method for a practical technical module for a non-technical BI course (Wang and Wang, 2013), and an experiential learning approach in teaching BI (Podeschi, 2014).

Game technology is one approach that has been used to support the development of new skills, for instance, creativity, initiative, responsibility, team-working, managing, and meta-cognitive skills (Redecker et al, 2011). Game characteristics such as competition, goals, choice, rules, fantasy, and challenges can contribute and sustain 21st Century skills (Romero, Usart and Ott, 2014). Moreover, business simulation games have been known as one of the most effective education methods for teaching and learning managerial skills (e.g., Faria et al, 2009; Wawer et al, 2013; Williams, 2011).

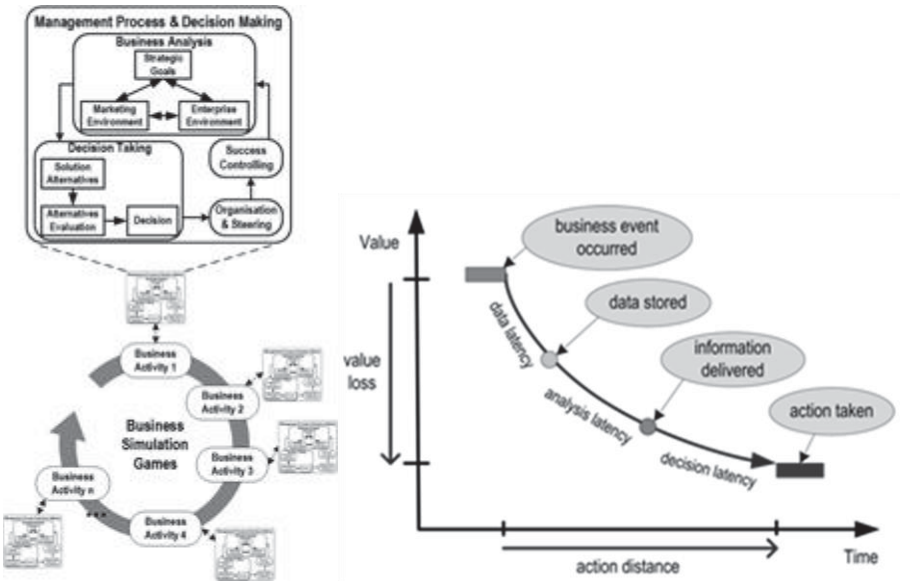
2. Teaching business intelligence in academia

In the field of Information Systems, there are many subjects based on Decision Support Systems and Business Intelligence concepts that have been taught for many years in academia; for example, Analytical Information Systems, Management Information Systems, Business Analytics, Decision Sciences, and Statistics (Power, 2007; Wixom et al, 2014). In a survey from BI Congress 2012 regarding the status business intelligence in academia, responses were obtained from 319 faculties from 43 countries, 614 students from 96 universities, and 446 practitioners (Wixom et al, 2014). The interesting findings were that the number of BI program offerings has dramatically increased as well as the access and usage of BI teaching resources. While the demand for BI students has surpassed the supply, the foundational skills are still the most critical for new BI technology and employers were not satisfied with the graduates' practical skills. There were several key challenges in teaching BI such as access to data sets, finding suitable cases, providing realistic and meaningful experiences. The universities were requested to prepare students for positions as general business analysts, IT professional who can work with data or analytics, or data-savvy business people. Moreover, it was noted that students should have communication skills and experience in report or dashboard development. The employers also indicated the challenges of hiring students for BI jobs as: lack of experience; insufficient business skills, technical skills, communication skills, critical thinking, and data skills, and inexperience with real tools and real data.

The *BI Academy* (BIA) (www.bi-academy.eu) is a government-funded project that has developed a web portal for teaching BI, hosted at the Stuttgart Media University, Germany. The study programme – Information Systems and Digital Media at the Faculty of Information and Communication – offers several BI-related courses: Management Information Systems, Analytical Information Systems, Data Warehouse System, and Business Intelligence. To provide realistic and meaningful experiences in learning BI, a business simulation game has been developed as an educational platform and a blend of traditional face-to-face teaching. This is a proven approach as business simulation games have been used in business schools for a half century and there have been several empirical studies indicating that this approach enables students to learn how to make a decision, manage the business process in a modern enterprise, link abstract concepts to real world problems, and improve quantitative skills (e.g., Ben-Zvi, 2010; Wawer et al, 2013; Williams, 2011). However, many commercial business simulation games can be very complex and have been developed based on different learning objectives, for instance, inventory management, strategic management, marketing management, or business management. Therefore, our BI game was developed to be less complex and of a smaller scale and, in particular, it supports only some basic functions of an Enterprise Resource Planning (ERP) system. The *"Order-To-Cash"* process was selected as a study area and the BI game focuses more on managerial decision support.

3. The conceptual and technical frameworks

The conceptual framework as shown in Figure 1a consists of two parts: the Business Simulation Games and the Management Process & Decision Making. The business simulation game is used as an educational platform to simulate the business processes. Each business activity, which occurs during a business process, requires someone to manage it and make a decision. The strategic goals, the marketing environment, and the enterprise environment should therefore be analysed. The alternative solutions should be evaluated, selected, implemented, and controlled for success (Gluchowski, Gabriel and Dittmar, 2008). The cycle of management process and decision making have to be done as soon as possible after the business event occurred to keep the business value high (Figure 1b) (Hackathorn, 2003), which can be achieved by using BI as an information service in a company. Based on this, the technical framework shown in Figure 2 was developed using the data warehouse approach to support the business scenarios as well as the management processes and decision making from the conceptual framework. A data warehouse *"is a subject-oriented, integrated, non-volatile and time-variant collection of data in support of management's decision making process"* (Inmon et al, 2008, p.7).



(a) (b)

Figure 1: (a) The conceptual framework for the BI game and (b) the value-time curve

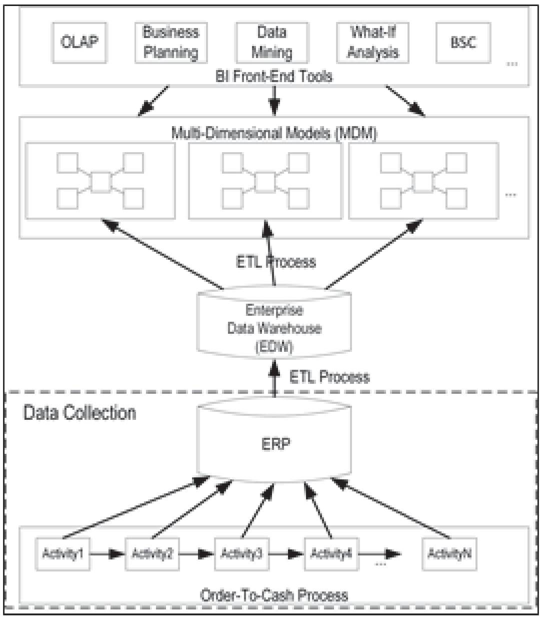


Figure 2: A technical framework for the BI game

With this technical framework, the business transactions from the Order-To-Cash process are collected into the game ERP server. The Order-To-Cash process includes several business activities, for instance, order entry, distribution, invoicing, and customer payments. The key figures (e.g., sales amount, revenue, and cost) are generated and stored in the Enterprise Data Warehouse (EDW). All transactional and master data are stored as a relational data warehouse model (Figure 3). This model is also called a multi-fact schema. Next, a Multi-Dimensional Model (MDM) is designed and an ETL process is developed to populate the analytical data from the enterprise data warehouse to the multi-dimensional model in order to access, analyse, and visualise data with the BI front-end tools. Consequently, the business analytics can be carried out to improve the business performance.

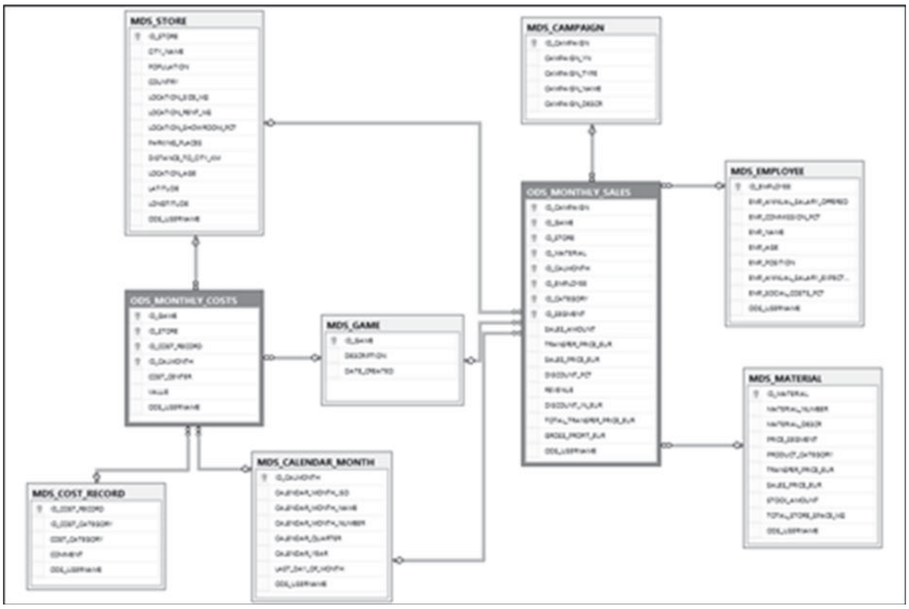


Figure 3: The relational data warehouse model

4. Description of the BI game

The prototype of the BI game was launched in February 2014 and has been tested with students at several European universities. The tasks in the BI game are the development, the implementation, the analysis of the impact and success of a business plan, and the refinement of a business plan. The BI game has been developed based on a closed-loop approach, therefore, the BI game simulates a real business process and students have to take a role of a decision maker, analyse the key figures, calculate the profit as a result from their actions, and react from their own decisions to improve the next decisions (Lee, 2010).

4.1 BI game scenario

The game is based around a fictitious company that specialises in selling high quality bicycles and accessories, for instance, mountain bikes, kid bikes, e-Bikes, event bikes, tires, helmets, gloves, and baskets. The company has an expansion strategy to increase the market share by opening more bike stores around the country. The organisational format of the BI game has four main steps (Figure 4) as follows: (1) Introduction; (2) Business Parameters Setting; (3) Data Collection & Simulation, and (4) Refinement. In the first two steps, students attend an introduction session then develop and implement a business plan by setting the initial business parameters. In the third step, the initial business parameters and the simulated business transactions for the business activities are collected and stored in the ERP server. In the fourth step, the key figures are simulated and stored in the enterprise data warehouse. Next, the BI assignments are provided to students. The first two BI assignments belong to the *'Build BI'* module which consists of the "Multi-Dimensional Modelling" and the "ETL Design & Process" phases. The 'Build BI' module is designed for students to prepare and deploy the analytical data. The other assignments belong to the *'Use BI'* module, which consists of the "Sales Analysis with OLAP" and the "OLAP-Based Business Planning" phases. The 'Use BI' module is designed using different business scenarios where students perform business analysis and refine their business parameters (Step 4 Refinement). Then, the key figures are calculated and simulated again based on the modified business parameters for the next business analysis.

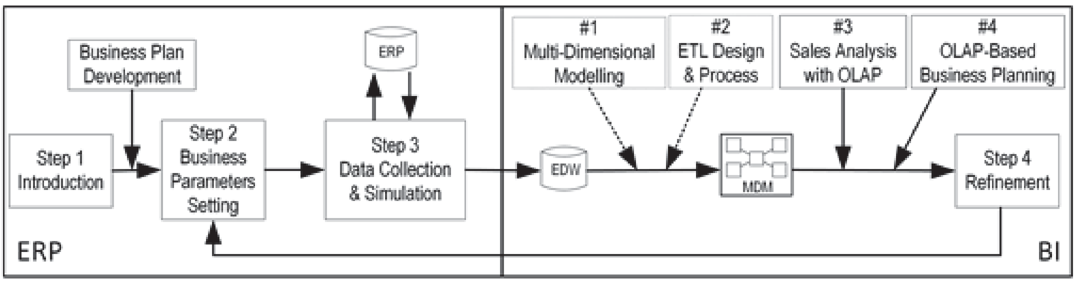
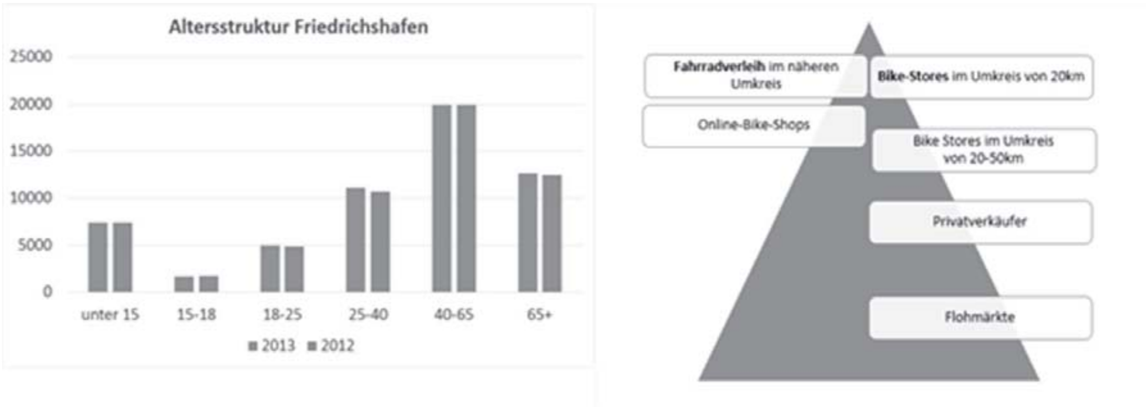


Figure 4: The organizational format of the BI Game

4.2 Step 1 to Step 3: Introduction, business parameters setting, and data collection & simulation

Students are introduced to the BI game and the bike market situation in a specified country. Later, students are randomly assigned to teams of three to four. Each team is responsible for a city and for opening a new bike store in that city. Each selected city including its surrounding areas contains approximately 200,000 – 250,000 inhabitants; for instance: Freiburg im Breisgau, Friedrichshafen, Karlsruhe, and Heidelberg. This is considered an appropriate size for the city in our game.

Each team represents a management team that is responsible for a bike store. Each store has a similar size of about 500 m^2. The teams have to collect all relevant market information, for instance, the landscape profile, population, target group (Figure 5a), bike market volume, and competitors in the city (Figure 5b). Then they present their business plan using the following structure: location, target group, competitors, product mix, marketing campaign, personnel plan, and financial plan. An instructor who serves as an executive of the company assigns an initial market share based on the quality of the proposed business plan.



(a) (b)

Figure 5: Example of a business plan: (a) target groups and (b) competitors

After that, the teams register in the BI game application and set their initial business parameters. They select a store for rent, order products from the company stock, consider and choose staff, and select the marketing campaigns (Figure 6). Furthermore, they can add more new stores to the system, request more new products from the company, or create additional marketing campaigns.

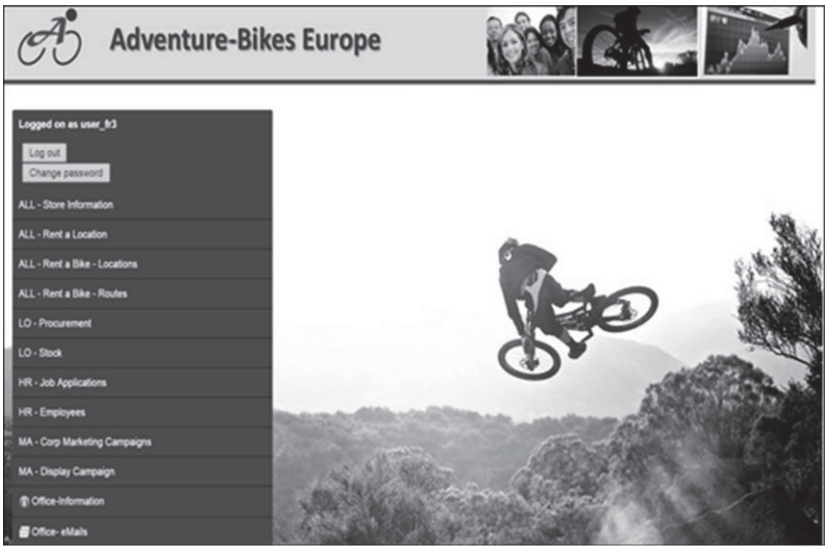


Figure 6: A screenshot of the BI game application for the initial settings

Based on those inputs, the data generator calculates all business transactions to store in the ERP server. This calculation is based on the data from real bike companies that have a similar size of business and serve as a model or benchmark. The factors that influence the success of the bike business are as follows: location parameters, product mix for the region, qualification of the employees, good marketing campaign, real weather, and real sport events (e.g., Tour de France). The key figures are calculated and stored in the enterprise data warehouse. At this point, the 'Build BI' assignments are provided to students to prepare the analytical data. Students are able to access the enterprise data warehouse in order to design a multi-dimensional model (Figure 7) and design an ETL process (Figure 8) to populate data from the enterprise data warehouse into the multi-dimensional model.

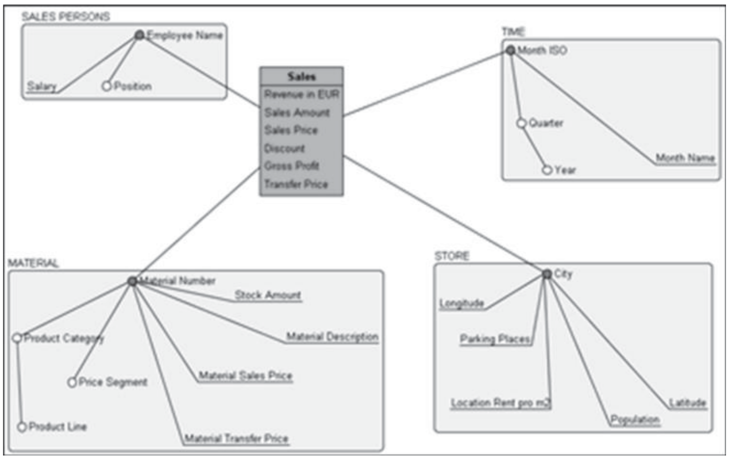
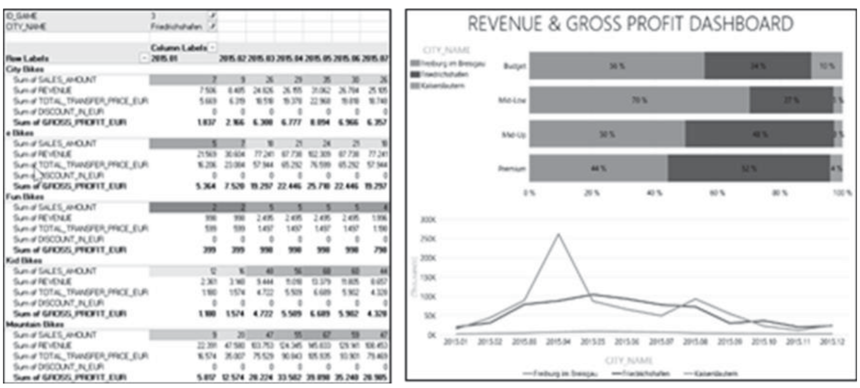


Figure 7: A multi-dimensional model for sales performance

Figure 8: An ETL process to populate data from the enterprise data warehouse to a multi-dimensional model

4.3 Step 4: Refinement

Before the teams can begin their refinement, they are provided with the 'Use BI' assignments. The "Sales Analysis with OLAP" assignment helps students to learn how to analyse their sales performance by using an OLAP tool (Figure 9). Students are able to see the results from the implementation of their initial business plan and they have a chance to reflect on their decisions and improve the next decisions by refining their business parameters.



(a) (b)

Figure 9: Examples of the sale analysis: (a) an OLAP report and (b) a revenue-gross profit dashboard

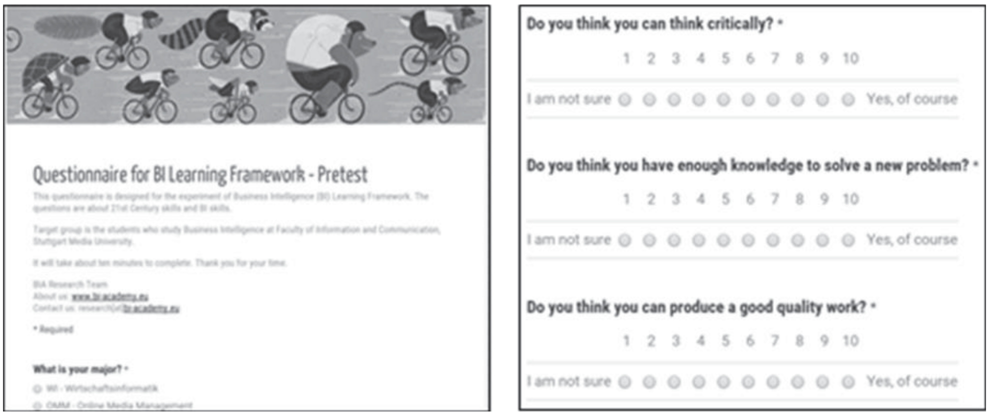
The next assignment – "OLAP-Based Business Planning" – helps students to learn business planning by using OLAP tools. Students are able to focus on good practice in doing an OLAP-based business planning and can see the results from the previous decisions, have a chance to reflect and improve the next decisions by refining their business parameters. Working with the 'Use BI' assignments, students are able to analyse the impact and success of their business plan and refine it. Then, the data generators calculate the values for their key figures.

5. Learning evaluation

It is anticipated that teaching BI with a business simulation game will help students to develop their 21st century skills and BI skills. Today's BI users need to have at least three groups of skills: (1) analytical skills – e.g., data mining, statistical analysis; (2) IT skills – e.g., data mart model, ETL process, and (3) business knowledge and communication skills – e.g., business functions, ability to explain what is being analysed (Andoh-Baidoo et al, 2014). Additionally, the 21st Century skills are also needed for the next-generation BI workforce. The evaluation for students' skills from learning with the BI game will be collected from self-assessment, peer assessment, group assessment, game results, quiz, and BI assignments.

5.1 Questionnaires

The initial version of the BI game has been evaluated in session 2014-15 with 16 students from the 4th to 6th semester some of whom would have some background knowledge in Business Intelligence and also some related skills. Students were asked to complete a pre-test questionnaire before or during the initial session of the BI game or the traditional BI class. The pre-test questionnaire consisted of three parts: personal information, 21st Century skills, and BI skills (Figure 10). Students' major and ID were collected to match the results from other assessment methods. Likert-scales with ten items were used to collect students' self-assessment.



(a) (b)

Figure 10: (a) The pre-test questionnaire and (b) some questions about 21st Century skills

Questions 1 and 2 were about personal information, questions 3 to 18 were about 21st Century skills, and questions 19 to 25 were about BI skills (see Table 1). The self-assessment results were grouped into three categories: 1 = low, 2 = medium, and 3 = high. Later, students were asked to complete a post-test questionnaire after the last session of the BI game or the traditional BI class. The post-test questionnaire consisted of three main parts: preferences and perceptions, skills, and gaming features. Likert-scales with ten items were used to collect students' self-assessment.

Table 1: The questions in pre-test questionnaire

Question	Personal Information	Question	21st Century Skills	Question	BI Skills
1	Major	3	Teamwork	19	OLAP tools
2	Student ID	4	Communication	20	OLAP-based Business Planning
		5	ICT literacy	21	Multidimensional Modelling
		6	Social or cultural skills	22	ETL process
		7	Creativity	23	Data Mining
		8	Critical thinking	24	BI concepts
		9	Problem solving	25	BI tools
		10	Productivity		
		11	Learning to learn		

Question	Personal Information	Question	21st Century Skills	Question	BI Skills
		12	Self-direction		
		13	Planning		
		14	Team flexibility		
		15	Idea flexibility		
		16	Risk taking		
		17	Conflicts management		
		18	Sense of initiative		

5.2 The preliminary results

The first pre-test questionnaire was completed by an experimental group. It showed that most of students assessed themselves as having relatively high 21st Century skills (Figure 11). About 55-60% of the students assessed themselves for most of questions as having high or medium 21st Century skills. However, the students who assessed themselves having high skills in creativity (Question 7) and in handling uncertainty (Question 16) were only 19% and 13% respectively.

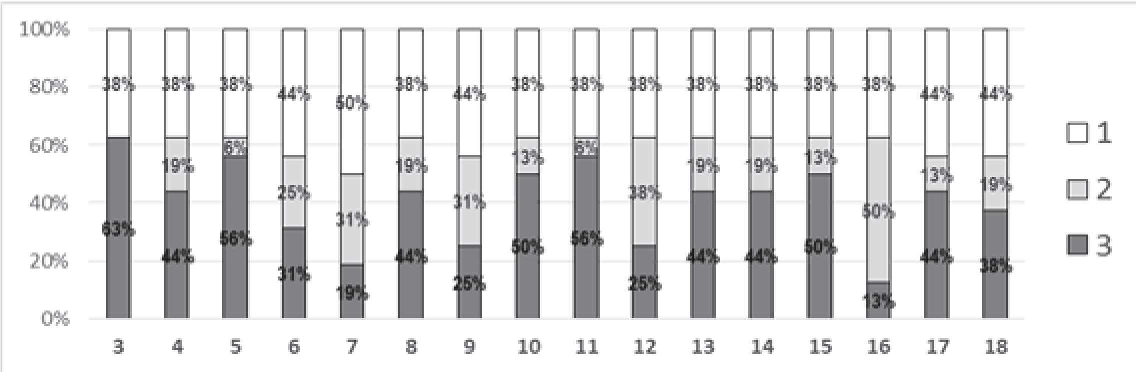


Figure 11: The preliminary results of the pre-test for 21st century skills from the experimental group

On the other hand, about 80-85% of students assessed themselves as having only medium or low BI skills (Figure 12). Moreover, for questions 22 to 25 – ETL process, data mining concepts, BI concepts, and SSBI tools, respectively – no student assessed him- or herself having high skills. These results suggest that the students have good 21st Century Skills but need to improve their skills in Business Intelligence and they will hopefully benefit from the use of the BI game.

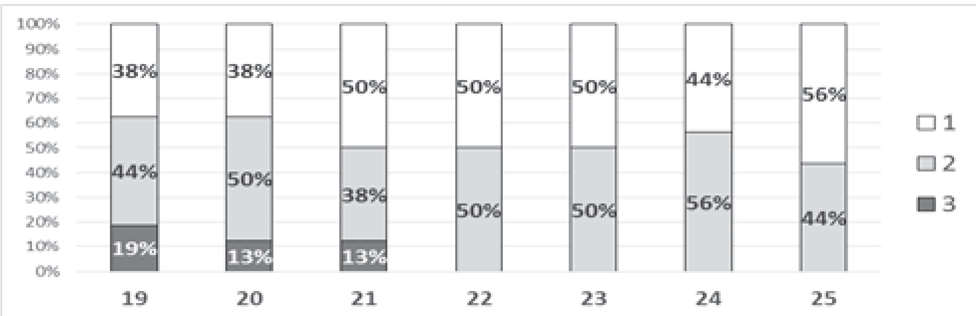


Figure 12: The preliminary results of the pre-test for BI skills from the experimental group

The preliminary results concerning BI skills from the post-test of the experimental group (see Figure 13) showed that no student assessed him- or herself as having low BI skills anymore. About 67% of the students assessed themselves as having high BI skills in OLAP tools compared to 19% in the pre-test. About 60% and 80% of students assessed themselves as having high BI skills in OLAP-based Business Planning and Multidimensional Modelling respectively compared to about 13% in the pre-test. About 73% and 60% of students assessed themselves as having high BI skills in ETL process and Data Mining respectively compared to no students having assessed themselves as having high skills in the pre-test.

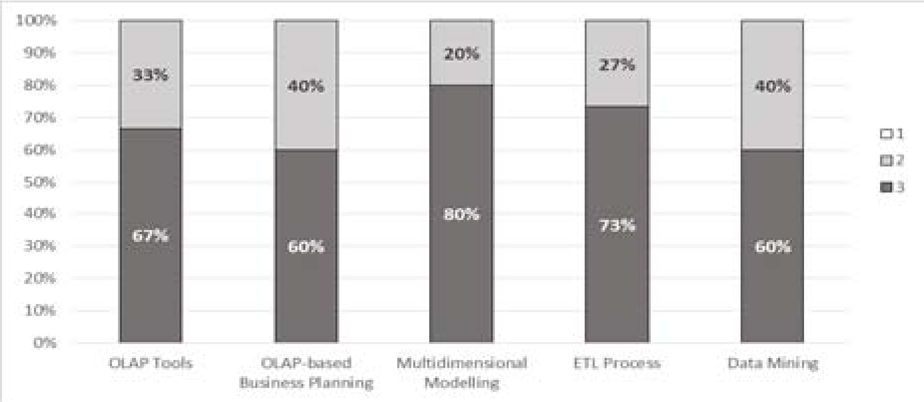


Figure 13: The preliminary results of the post-test for BI skills from the experimental group

Additionally, about 67% of students assessed themselves as having learned more with BI game. They stated that they liked the practical part together with realistic scenarios and real tools, and gained experiences from learning with the BI game. Some positive quotes from students were:

> *"I liked the practical way of learning with the game."*
>
> *"I liked the structure of the course. The combination of practical work with tools and the theoretical background."*
>
> *"I liked the practical experience. For me it is easier to learn with a realistic scenario with the opportunity to act on it than to just hear the lecture."*

6. Conclusions

With this BI game, instructors are able to put theory into practice with a risk-free and inexpensive environment. Students can be trained in a relatively short period of time with a realistic business scenario and they can experience real data and real tools. Students are provided with a closed-loop environment, which helps students to learn to manage the performance of the business processes and helps them to align business goals and processes consistently (Martin, 2014). Additionally, students are able to understand the impact between each business process because it involves human intervention to improve the way decisions are made (Kerremans and Kitson, 2012).

The advantages of the BI game are: more BI assignments or modules (e.g., data mining, what-if analysis, balanced scorecard dashboard, geographic information system, or big data) can be added to the game; the duration of running the game is quite flexible, and the system's scalability can handle a large number of players concurrently. We believe that the BI game provides a modern, integrated, and easy-to-use educational platform. Students will improve both their BI skills and 21st Century skills through the learning process and gain a better understanding of how to use decision support technology.

A full version of the BI game is being developed that will include three more BI assignments: Data Mining, What-if Analysis, and Balanced Scorecard Dashboard, which will be able to leverage BI maturity to a higher level. This version will be evaluated using an RCT/quasi-experimental methodology using pre-test/post-test questionnaires to assess the impact on learning.

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Approximating Balance in Collaborative Multiplayer Games

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Abstract: Multiplayer games allow players to play together, allowing them to train their socials skills and enabling collaborative learning in educational settings. But while balancing a game's challenge is a well-researched topic, to the best of our knowledge there are no definitions and algorithms taking into account the individual contribution of each player in a collaborative setting. Unequal contributions however can lead to one player completing the game alone while the others are not playing at all in the worst case. In this paper we provide a novel definition for collaborative balancing suited for multiplayer games with fixed and free roles, including metrics for heuristically calculating effort, waiting times and options available for each player. These metrics have also been implemented in a graph-based analysis algorithm, which has been applied to an example game in order to show the feasibility of this approach.

Keywords: multiplayer, collaborative, cooperative, balancing

1. Introduction

It has been shown that well-designed multiplayer games can enable collaborative learning while also training the players' soft skills. When creating a game for a group of learners however, it is quite hard to guarantee that every group member will be exposed to the same amount of learning content and that they contribute the same amount towards solving the game. If this is not the case, multiple problems arise that negatively impact both the learning outcome as well as the players' motivation.

For example, players with pre-existing knowledge might be able to solve an unbalanced game on their own while the others do not take part in the learning process and thus do not receive the intended knowledge. The better players in turn could complain they had to solve all the tasks on their own or, depending on the game design, that they had to wait for the others constantly. This can be viewed as a balancing problem since the game's tasks must be distributed between the individual players in a fair manner.

This paper is structured as follows: First we discuss the related work on game balancing in Chapter 2. After that we provide a novel definition for collaborative balancing in Chapter 3 and corresponding metrics in Chapter 4. We then describe the prototypical implementation of these metrics in an authoring tool in Chapter 5, discuss its results when applied to an example game in Chapter 6 and conclude with a short summary in Chapter 7.

2. Related work

Although there is a general consensus that balanced games are fair towards their players, suggestions on which properties a game should have to achieve that differ widely.

Balance can be viewed on multiple levels. The first one is the game's design, which is independent of concrete players. For Sirlin a balanced game design provides equal chances of winning to similarly skilled players and presents them a large number of viable options during play. The utility value of these options can differ depending on the current situation, as long as there are no strategies that are always right or wrong (Sirlin 2002). Newheiser provides a similar definition, but notes a contradiction in multiplayer games: New players want to be able to win against experienced ones, but experienced players want win consistently due to their higher skill level. Therefore, he suggests a mixture between random and skill elements (Newheiser 2009). Adams in contrast states that the leading player should change frequently to make games more interesting, but the better player should always win after some time (Adams 2002).

To achieve a balancing between different options, Leigh et al. propose a coevolutionary algorithm that automatically develops strategies and then modifies the game in such a way that there is no dominating one. The drawback is that the space for potential strategies is often too large and therefore not every strategy can be tested (Leigh et al. 2008). Finding optimal solutions algorithmically has even been argued to be NP-hard (Chen et al. 2014).

Another level on which a game can be balanced is its runtime behaviour, where it might adapt itself to better suit differently skilled players. Andrade et al. used reinforcement learning to unnoticeably keep a singleplayer game balanced (Andrade et al. 2005). When multiple players play against each other it is also an option to quietly support the weaker player, which has been done in a shooting game (Bateman et al. 2011) and a racing game (Cechanowicz et al. 2014). It must be noted however that depending on the individual player's attitudes they might perceive such aids as unfair. Instead it might be more beneficial to match them against appropriate opponents instead (Delalleau et al. 2012).

Other sources of unfairness in a multiplayer setting are external factors such as latency issues (Zander et al. 2005) and players using illegitimate methods to gain an advantage (Yeung et al. 2006)

It must be noted that all of these approaches take a competitive view, i.e. the player playing against the game in a singleplayer setting or different players playing against each other in a multiplayer setting. Nevertheless, they could be applied in a collaborative setting for balancing the players as a group against the game. However, to the best of our knowledge there are no definitions or metrics that take the interplay between the collaborating players into account. This is especially important since it has been shown that in working environments effectiveness and the amount of social interactions increases when workers feel like they are treated fairly (Whitman et al. 2012), which is also relevant in collaborative learning settings.

3. Definition: Collaborative balancing

In order to balance collaborative games where players work together to achieve a common goal, e.g. reaching the end of the game, a new definition including the interplay inside teams of any number of players is needed.

When talking about fairness in a team most people are interested in individual contributions. It is perceived as unfair if only a part of the group is doing the actual work while others profit from their effort, which is also known as free-riding (Strijbos & De Laat 2010). This is especially problematic in a collaborative learning setting, where participation means being exposed to the learning content. Therefore, players that do not actively take part might miss some of the learning content. It is easy to see that all players should contribute roughly the same amount of effort. Waiting times are directly related to the effort other players provide and should be balanced as well.

It has been argued in competitive definitions that it is also beneficial to provide a variety of interesting decisions. In a collaborative setting this must not only be true for the group as a whole, but for each individual player. A player role that forces a player to repeat a single action over the course of the whole game will not be very interesting, even if the group as a whole can choose different paths through the game. Similarly to effort, options should be balanced between the players.

We therefore provide the following definition for a collaborative balancing:

A collaborative or cooperative game is considered balanced between group members when the individual efforts and waiting times required to solve the game as well as the number of options a player has along the way are equally high and uniformly distributed throughout the game.

4. Approximating collaborative balance

In order to measure how balanced a game is the abstract concepts of effort, waiting times and possibilities must be mapped to actual game elements. Since players interact with games using actions like clicking a button or pressing a key, these actions can be used for approximating the balance (with an additional weighting to model their difficulty or complexity).

These actions can be available for any player or for specific players / roles only. If they are available for multiple roles it must be decided during play which player should perform those tasks. This places some responsibility on the players, which is more interesting for them and gives them room to train their social skills, e.g. by discussing different alternatives. The drawback of freely available actions is that they cannot be attributed to a single player during design and so the balance may vary based on how the game is played later on.

Most games are also non-linear so that players can take different paths to the game's ending, either by choosing between multiple options or by taking optional detours. To accurately measure the balance it would therefore be necessary to count the player actions on every path. As some paths are more obvious they should also be weighted based on the probability with which they are chosen. This probability however is not known and in most cases an infinite number of paths through the game exist, for example when players are able to move back and forth through several rooms. But even without such loops the number of paths through most games is still too large to be checked exhaustively.

We therefore suggest a heuristic solution as a trade-off between accuracy and runtime. This heuristic uses the state space graph of the game, which contains all possible game states as nodes and ways for the players to trigger transitions between them. It then calculates all possible end states e, which does not only include different game endings, but also different ways to reach a single ending resulting in differently set game variables. Then for every player p_m the path to each ending that minimizes a certain metric (e.g. effort) for this player $minPath(e, p_m)$ can be calculated to get a lower bound of that metric, so the player must contribute at least this effort for the group to reach this ending. It is necessary to calculate those paths for each player independently since the minimal path might be different for each player.

Maximizing instead of minimizing is not feasible in most cases since loops could lead to infinite maximum paths. If the state space is not available it is also possible to calculate the solutions for the game with appropriate AI algorithms and to use these as paths instead. If the number of possible paths is still too high a random sample can be used instead.

After the minimal paths $minPath(e, p_m)$ of each player p_m to each ending state e are known the effort for all player p on this path $E^{p}_{p_m,e}$ can be calculated, which yields the effort each player p has to contribute in order to minimize the effort of p_m. This effort is defined by the combined effort of all actions on the path that only one particular player p can trigger. Actions that can be triggered by multiple players do not count towards the minimal effort of a certain player, as no player is forced to perform them.

$$E^{p}_{p_m,e} = \sum_{a \in minPath(e,p_m)} effort(a,p) \qquad effort(a,p) = \begin{cases} weight(a), & only\ p\ can\ trigger\ a \\ 0, & else \end{cases}$$

The combined effort of all actions on this path $E^{all}_{p_m,e}$ is the sum of all efforts on this path. Since our model supports actions that can be triggered by multiple players it differentiates further between this sum and the sum of all actions that can only be triggered by a single player ($E^{any}_{p_m,e}$).

$$E^{all}_{p_m,e} = \sum_{a \in minPath(e,p_m)} weight(a) \qquad E^{any}_{p_m,e} = \sum_{i=0}^{n} E^{i}_{p_m,e}$$

In a game where every action is assigned to a single player these two values are the same and the effort can be calculated accurately. But if many actions can be triggered by multiple players these values differ and the approximated balance can be changed greatly by the players themselves depending on who execute these flexibly assigned actions. The accuracy of the calculated effort $A^{E}_{p_m,e}$ can therefore be calculated by comparing these two values to each other.

As different paths through this game might require a different overall effort one should not compare the minimal effort of each player on different paths, but the percentage this player has to contribute compared to the others ($E^{p\%}_{p_m,e}$). On each ending e these should be similar for each player.

$$A^{E}_{p_m,e} = \frac{E^{any}_{p_m,e}}{E^{all}_{p_m,e}} \qquad E^{p\%}_{p_m,e} = \frac{E^{p}_{p_m,e}}{E^{any}_{p_m,e}}$$

While the effort is defined by the actions a certain player must take, the waiting time is the effort a player is not able to participate in as he or she must wait for someone else to complete them. An action that multiple players are able to perform is therefore neither effort nor waiting time for any of them, as they can execute it but are not forced to do so. As such, the formulas for effort and waiting time are similar with one important distinction: The waiting time percentage is based on the value of all actions, not on those that can be uniquely assigned to one player as everyone else is waiting when one player acts. Therefore, there is also no accuracy for this value.

$$W^{p}_{p_m,e} = \sum_{a \in minPath(e,p_m)} waiting(a,p) \qquad waiting(a,p) = \begin{cases} 0, & p\ can\ trigger\ a \\ weight(a), & else \end{cases}$$

$$W^{all}_{p_m,e} = \sum_{a \in minPath(e,p_m)} weight(a) \qquad W^{p\%}_{p_m,e} = \frac{W^{p}_{p_m,e}}{W^{all}_{p_m,e}}$$

This approximation only counts actions which are required for solving the game (i.e. they lay on the minimal path to an end state). In some cases waiting players could perform optional actions or even trigger a required action in parallel, which is not represented in this calculation.

The options each path offers to the players can be calculated like the waiting time, using the possible actions for each player after each step as the metric.

$$O^{p}_{p_m,e} = \sum_{a \in minPath(e,p_m)} options(a,p) \qquad options(a,p) = \sum_{o \in successors(a)\ |\ p\ can\ trigger\ a} weight(o)$$

$$O^{all}_{p_m,e} = \sum_{o \in successors(a)} weight(o) \qquad O^{p\%}_{p_m,e} = \frac{O^{p}_{p_m,e}}{O^{all}_{p_m,e}}$$

Instead of calculating individual paths for waiting times and options, their calculation could also be based on the effort optimizing path. This trades accuracy – there might be a path with a lower metric – for a greatly reduced runtime as fewer path must be calculated.

After the percentages of each metric for every player and path are calculated they must be aggregated to get the overall picture. As the players' values for a specific ending should be similar their standard deviation over all paths should be minimal, which can be used as an aggregation metric. It must be noted however that although the mean percentages lie in the interval $[0,1]$, the worst case standard deviation SD_{worst} (one player does all the effort instead of the optimal $\frac{1}{n}$ distribution) is dependent of the number of players n. In order to compare the standard deviations of any metric x over different games they should therefore be normalized in relation to SD_{worst}.

$$SD_{worst} = \sqrt{\frac{\left(1-\frac{1}{n}\right)^2 + (n-1)*\left(0-\frac{1}{n}\right)^2}{n}} = \frac{\sqrt{(n-1)}}{n} \qquad SD_{norm}(x) = \frac{SD(x)}{SD_{worst}}$$

Finally, the normalized standard deviations for effort, waiting time and options as well as the accuracy for each ending state must be interpreted: If the average and maximum of the standard deviations is low the game is balanced (the metrics are similar for all players). If only the average is small most paths are balanced except a few outliers and if it is high most paths are unbalanced.

The accuracies average and minimum over all paths describes how much the result can be modified by players executing actions that are also available to others. Averaging the absolute effort, waiting time and possibilities for each player instead of looking at the standard deviation can show which players are favored by an unbalanced game. These values can be similar however, even if the standard deviation is high. This means that each path through the game favors different players, so advantages equalize themselves over all paths. Since few players play the game many times using different paths, this is still a balancing problem.

If the analysis shows anomalous values the algorithm highlights problematic paths as sequences of player actions, which allows authors to modify them, for example by assigning actions to other players. Since all of these metrics can be calculated during the design / authoring phase, the balancing can be approximated without a working game or playtesters.

The overall algorithmic complexity of this approach is defined by the path finding algorithm, which must be run for each combination of player and end state.

5. Implementation

We implemented this approach for approximate balancing calculation in our authoring tool StoryTec (Mehm et al. 2009), with which authors can create scene-based single- and multiplayer games. Therefore, the balancing calculation can be performed on any game created with the tool, although it can only show the overall effort for singleplayer games.

The state space calculation is provided by an existing algorithm for transforming games into petri net models in order to detecting structural errors (Reuter et al. 2015). The authoring tool then uses the well-known Dijkstra's algorithm for calculating the shortest path to each end state. It's faster A* extension which uses a heuristic to guide the search in promising directions first can also be used if there is a known lower bound for the costs from each node to the end. A valid bound would be the number of actions to the end goal, which can be obtained with a breadth-first-search on the graph starting from the end node. This calculation must be repeated for each end node, but can be re-used for every player. Since this operation also takes time, it is more beneficial to use A* for a larger number of players and for state spaces where it performs especially well compared to Dijkstra, i.e. in graphs that expand in multiple directions. Therefore, both options were implemented.

For approximating the weight of individual actions multiple heuristics were developed, based on the principle of ActionSets used in the authoring tool. An ActionSet is a tree of game (re-)actions to a user input stimulus with branches based on variable conditions. The first heuristic just counts the user inputs and treats every ActionSet the same, assigning it a value of 1. The second one emphasizes the overall complexity of the tree, counting the actions it contains. Depending on the structure of the tree and the variables used in its conditions, only some of the actions might be executed in a given game state. To respect that the third heuristic counting the actually executed actions that change the game state (optional options like requesting hints are ignored). And last but not least authors can override each heuristic by manually setting the difficulty of ActionSets according to their expert knowledge.

In order to find the minimal value of each metric for a player a naïve approach could override all transitions that could be triggered by other players with a weight of zero, as they are not relevant for the minimum. However this would result in a greatly increased runtime, as the pathfinding algorithm would search all of these transitions first before triggering one by the player in focus (which it must do eventually if the action is required to solve the game). In order to not explore the whole state space it is therefore advisable to choose weights of at least one for those irrelevant transitions. As actions of other players must be favoured in order to find the minimal effort for the player in focus there must be a numerical advantage of those actions, so we propose to multiply the weights of these transitions with 20 instead. This means that if all player actions are judged equally complex the pathfinding algorithm would search 20 consecutive transitions done by other players before eventually considering one for the player whose effort should be minimized. This number can be tuned as a trade-off between searching the whole state space and correctness: If this player's action could be circumvented with 21 other actions the path would not be optimal and the calculated metric would be too high. But since the calculations are approximations anyway such an error is not critical.

If A* is used for pathfinding an additional heuristic for guiding the search is required, adding further constraints to the action weighting. The A*-heuristic must be admissible, i.e. its values must not be larger than the actual distance to the end state. Since the minimal number of steps towards the goal is used as this heuristic, the weight of every step cannot be smaller than one.

When calculating the final metrics for each path it is not necessary to take pathfinding costs into account, so the unmodified weights can be used.

6. Results

The implementation was then tested by analysing a well-received multiplayer adventure game (Reuter et al. 2012). The game is designed for two players and uses relatively strictly enforced roles, with most actions being assigned to one player only. Our user study had shown that players of both roles felt involved during the majority of the game, which means that according to our definition it was balanced for them.

The state space of a large subsection of this game spanning thirteen minutes of playtime has already been calculated in our previous work (Reuter et al. 2015). Despite having a single ending the game's state space contains 88 different ending states. We then applied our balancing metrics in various parameter combinations (Table 1) using different weight heuristics (input, complexity and actual actions), path calculations (optimizing effort only or each metric separately) and path finding algorithms (Dijkstra and A*).

Table 1: Evaluation results

			Time		Accuracy		Effort SD		Effort P1	Effort P2	Waiting SD		Options SD	
Weight	**Optim.**	**Pathf.**	**Imp.**	**Calc.**	**Min**	**Avg**	**Avg**	**Max**	**Avg**	**Avg**	**Avg**	**Max**	**Avg**	**Max**
Input	Effort	Dijkstra	2 s	7 s	0,92	0,99	0,08	0,17	20	20	0,08	0,17	0,02	0,07
Input	Effort	A*	2 s	4 s	0,92	0,99	0,08	0,17	20	20	0,08	0,17	0,03	0,07
Input	Sep.	Dijkstra	2 s	20 s	0,92	0,99	0,08	0,17	20	20	0,08	0,17	0,04	0,08
Input	Sep.	A*	2 s	11 s	0,92	0,99	0,08	0,17	20	20	0,08	0,17	0,04	0,08
Compl.	Effort	Dijkstra	2 s	10 s	0,75	0,97	0,11	0,25	90	97	0,13	0,26	0,13	0,18
Compl.	Effort	A*	2 s	7 s	0,75	0,97	0,11	0,25	90	97	0,13	0,26	0,13	0,18
Compl.	Sep.	Dijkstra	2 s	45 s	0,75	0,97	0,11	0,25	90	97	0,11	0,25	0,07	0,13
Compl.	Sep.	A*	2 s	25 s	0,75	0,97	0,11	0,25	90	97	0,11	0,25	0,07	0,13
Actual	Effort	Dijkstra	2 s	6 s	0,94	1,00	0,11	0,22	26	30	0,11	0,22	0,32	0,47
Actual	Effort	A*	2 s	4 s	0,94	1,00	0,11	0,22	26	30	0,11	0,22	0,32	0,47
Actual	Sep.	Dijkstra	2 s	24 s	0,94	1,00	0,11	0,22	26	30	0,11	0,22	0,16	0,33
Actual	Sep.	A*	2 s	13 s	0,94	1,00	0,11	0,22	26	30	0,11	0,22	0,16	0,33

The weight heuristic is most influential as it governs the impact of each individual player actions on the overall result. As complexity results in the largest value range of individual actions it also results in a larger variance in balancing, i.e. an average effort balance of 0.11 (worst case 0.25). This is due to single complex action skewing the result towards a single player. Using actual effects and input in contrast suggests that the game is more balanced, i.e. 0.11 (worst case 0.22) and 0.08 (worst case 0.17). Therefore authors must select a heuristic that is most appropriate for the game under test over even annotate actions using their own weights. As the overall value range is between zero and one (one indicating completely unbalanced games), all of these values however suggest a relatively balanced game.

When investigating the absolute effort player two has to provide 1% to 16% more effort over all paths, so the slight unbalance could be improved by shifting some actions to player one. The accuracy of these results is greater than 97% on average with a worst case of 75% on individual paths, meaning that there are only few actions that the players can choose to distribute themselves in order to influence the balancing. As the ActionSets behind those actions are relatively complex compared to the other ones their influence is most obvious when using this metric.

Waiting times are also pretty balanced, with an average standard deviation of up to 0.13 (worst case 0.26). The possibilities produce reasonable values as well, 0.16 on average, but the worst case of 0.33 suggests that there are some paths through the game that do not balance the possibilities well. It is also interesting to note that this value gets much worse (0.32 instead of 0.15 on average) when there is no separate path calculated for the possibilities, as the effort path minimizes a completely different metric. The waiting times in contrast do not vary much when calculated on an effort path, as the metrics are similar to each other.

In regards to computation time the initial setup including state space import takes about two seconds, the actual balancing calculations vary between ten and twenty seconds when only effort paths are calculated. As expected, this time is nearly tripled when the paths are also calculated for the other two metrics. Since our results already showed that effort and waiting time are quite similar, a better approach would be to only calculate effort and possibilities, doubling the time. The runtime can be decreased further by using the A*-Algorithm instead of Dijkstra, which took 25% to 50% less time for our example game while yielding the same result. Nevertheless, all of these calculations can be done in almost real-time and therefore can be calculated quite often during development.

7. Conclusion

In this paper we proposed a balancing definition explicitly addressing collaborative games where multiple players work towards the same goals. This definition includes the effort required by each individual player to solve the game, their waiting time and the possible actions the game provides for them. We then developed an approach and formulas to approximately calculate the balancing of any given game and implemented this concept into an authoring tool for scene-based games. Using this implementation we showed that an example game that was described as generally balanced could indeed reach good values and that the calculations could be done in a reasonable time span of less than a minute.

A current limit of this work is that while the general definition and concept can be used for any collaborative game, the implementation and results focus on scene-based games. As the state space of games from other genres is comparatively large it is not always possible to exhaustively calculate every path through them. It is therefore necessary to implement alternative path calculations in order to apply our approximations to other games as well, which will be part of our future work.

Other future work will include not only pointing out imbalances, but extending our algorithms to also provide suggestions on how to fix anomalies. While being straightforward in unambiguous cases where every path through the game favours the same player, modifying actions in cases where only some paths are unbalanced might impact formerly balanced paths as well. Suggesting changes therefore constitutes a separate optimization problem. And aside from balancing the game during its creation, future work could also balance the game during runtime for differently skilled players by re-assigning responsibilities on the fly.

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Serious Games Design as Collaborative Learning Activity in Teacher Education

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Abstract: Serious games design can be carried out as a collaborative, project based learning activity in the framework of a course on the use of ICT in education for future teachers. The main idea of the course is to combine all didactic and technical knowledge that students have acquired during their studies at the faculty of education and to apply it in a relatively complex project. All activities in the project can help them to achieve competencies that are crucial for teachers in primary and secondary schools. We have considered issues that are associated with collaborative learning and with different aspects of work in a group in the paper. We analyzed project activities in the courses in the last five years to find out how groups form, how the members of a group organize their project activities, and how they communicate and coordinate their activities in a group. We also investigated how a group size and its heterogeneity, complexity of the project, and communication media influence interactions in a group and what are the characteristics of interactions of a group with other groups and with external resources.

Keywords: game based learning, project based learning, collaborative learning, constructivism

1. Introduction

Rieber, Smith, and Noah stated already in 1998 that there are two distinct applications of games in education: game playing and game designing. Game playing is the traditional approach where one provides ready-made games to students (Tobias, Fletcher & Wind, 2014). Learning by designing is a central idea in constructivism (Harel & Papert, 1990; Perkins, 1992). Game designing assumes that the act of building a game is itself a path to learning, regardless of whether or not the game turns out to be interesting to other people. The idea of "learning by designing" is based on the assumption that active participation in the design and development process is the best way to learn something. Some experiences with children support game design as an authentic, meaningful approach for students to situate school learning (Rieber, Luke & Smith, 1998). This approach has gained increased prominence due to the proliferation of computer-based design and authoring tools.

At the Faculty of Education, University of Ljubljana we started to implement this approach six years ago in the framework of the two-semester course "Application of ICT in education" for future computer science teachers. There have been a lot of different approaches, methods and ideas developed on how to organize the process of designing and developing educational game from the initial idea into to final product. We could not agree completely with any of them so we decided to develop our own method, called 'SADDIE' (Rugelj & Zapušek, 2014).

In the beginning, our main focus was on creation of educational games with a high learning value, but it turned out later that the method had in fact two important outcomes. The first outcome is a serious game itself. Soon it became clear that this is actually only a side effect of the second goal, which is to motivate our students to work actively and to learn in an efficient way through carefully defined process of active engagement in the game design and production process (Rugelj, 2015). Students improve competences that are crucial for future teachers (Nančovska Šerbec & Rugelj, 2006). Such competences include the ability to determine learning objectives that are consistent with the curriculum, the selection of appropriate teaching approaches and their implementation in the learning process, the ability for organizing active and independent learning, qualification for the assessment of learners' achievements and for preparing feedback information, the ability for communication with experts from educational fields, qualification for considering the principles of human-computer interaction, qualification for critical analyses and evaluation of the learning environment, application of social, professional and ethical aspects related to ICT, knowledge for effective integration of ICT into the field of education, qualification for evaluation of acquired knowledge and of a learning process, and a competence for teamwork .

2. Game design as project based learning activities

Serious games design is implemented as a project in a course with a total of 8 ECTS credit points. It means that the students are supposed to spend between 220 to 240 hours in the project activities. The main idea of the course is to combine all didactic and technical knowledge that students acquired during their studies at the faculty and to apply it in a relatively complex project. According to constructivist learning theory, the course has very limited number of traditional lectures. The lecturer presents only the main project requirements in the introductory phase of the project and some general rules about the learning goals and about organization of work are defined. Students then follow 'SADDIE' methodology that defines framework phases and other incidental activities.

When after a few years we have realized that this approach was efficient, we decided to apply it to other similar undergraduate courses. First we offered it to our students in study programs Preschool education, Classroom teaching, Special education and Two-subject teacher as an elective one-semester course on serious games design. Another target group were visiting "Erasmus students" from different European countries in a course on use of ICT in education. In the previous academic year, similar course was offered to computer science teacher students at the Department of Informatics of the University of Rijeka, Croatia.

It was very interesting to observe how heterogeneity of groups (i.e. different disciplines, cultural background) and different previous experiences with constructivist approach to learning influenced group activities and learning efficiency.

3. Organization of work in groups

When we planned work in groups we took into account findings from the scientific literature (Gatfield, 1999; Gottschall & García-Bayonas, 2008). Students work in groups of 3 to 5 students, depending on the number of students in a course and on the complexity of a project. Students are free to form groups according to their preferences as we observed in the past that this approach gives the best results as regards students' motivation and efficiency of their work in groups. They usually group themselves according to experiences from previous group activities in other courses and according to friendships. The main problem represent individuals who are not well socialized and at the end of grouping process end up in a heterogeneous group of uncommunicative individuals, not willing to work together. In some rare cases in the past, where we were not successful in launching group work in such groups, we had to adapt the individuals' activities to a specific situation by assigning tasks to members of a group or to define mini projects for each individual. As such approach actually does not lead to all planned competences, it was used only in few exceptional situations.

In the courses where students do not know each other, as they come from different study programs or even from different countries, groups are formed at random. We advise students to create groups according to heterogeneous background and previous expertise in the fields, which are relevant for the project.

As developing teamwork skills is one of learning objectives for the course, it's important to assess students' progress toward that goal. We have to assess process, i.e. how students work, as well as product, i.e. the developed game and corresponding documentation. Process can be assessed according to a number of dimensions, such as the ability to generate a range of ideas, listen respectfully to different perspectives, distribute work fairly, resolve differences, and communicate effectively. Since we don't always have a direct insight into the dynamics of groups, we rely on reports from a group and on interactions in the learning management system that is used to support collaborative activities in groups.

Fair distribution of workload is connected with the problem of inactivity and laziness of certain individuals in groups. It appears in groups that are not coherent. The best measures to prevent such anomalies are, according to our experiences, regular groups' reports on their activities at plenary meetings, where all members of the group are involved, logging all the activities of the group in a blog, and peer evaluation within the group. In the regular weekly meetings, groups prepare oral reports on their work in the past week and on any problems they have encountered. They receive immediate feedback from peers and from the lecturer. If difficulties arise, the lecturer initiates discussion about what could be the reasons for a problem and gives some hints or suggests possible ways to solve them. These interventions are focused to actual issues in the design and production process and replace traditional ex-cathedra lectures.

As each project is assessed as a common result of work of all members in a group, the intra-group peer assessment is realized so that the sum of all ratings equals to zero. This means that a workload of inactive individual has to be assigned to one or more other members of the group. When the workload is equally distributed among all members of the group, all of them get score 0. Otherwise, inactive member gets a negative score and those who have to take their workload benefit by sharing the positive score. The final grade is calculated from a grade that the group earned for the project, corrected by peer assessment scores.

4. Group interaction patterns

The insight into reports, groups' blogs, and communications inside the LMS allows us to identify and analyze group interaction patterns. Group interaction refers to the activities that the group engages in to coordinate members, tasks, and tools (London & Sessa, 2007). Interactions can be analyzed by means of verbal statements exchanged between group members, accumulated over time in reports, blogs, and group communication support tools in the LMS. These interactions can help us to identify members' roles in the project, their engagement and commitment, mutual support, climate in a group, and task progress. It is interesting to identify how new ideas are generated in a group, how conflicts are resolved, how joint understanding is achieved, and how activities are coordinated in different phases of the project (Silberstang & London, 2009).

Interaction patterns are strongly affected by the size of a group, heterogeneity of its members, relations between group members, complexity of joint activities, duration of the project, and communication media.

4.1 Group size

As the groups in our project-based learning were relatively small (3-5), interaction patterns were simple and depended on the individual's roles in a group. In one third of the groups one of the members took over the leadership and other members accepted this. The leader played an important role in the discussions in the group, in the distribution of work and in its coordination. Usually, she was also responsible for the resolution of conflicts in the group. In presenting the work at the weekly meetings, she was "the first among equals", as on the course level formally all members were responsible for all the results of work of the group. Other roles, which are mentioned in the literature (Benne & Sheats, 1948), such as recorder, checker or spokesperson, did not appear in our groups.

The rest of the groups, especially groups of 3 or 4 members, have not formed any hierarchy and they made decisions and shared work by consensus. Some well-defined tasks were carried out in pairs.

4.2 Group heterogeneity

Group members in two courses had the same background (computer science teachers), while in the other two courses they had different background. We encouraged students in these two courses to form heterogeneous groups in order to learn more from their peers. In the international Erasmus course students came from different countries and brought different cultural models. Students with similar values and beliefs formed bonds more readily than those who perceive each other as different and students from northern countries more often worked together.

Students with different background needed more time to set up shared understanding of the problems that they faced, but their groups profit from width and diversity of knowledge of their members. Students from preschool and classroom education program had more in-depth didactic knowledge, students from two-subject teacher program have been better trained for technical aspects of the work, and students from special education study program contributed more to aspects connected with pupils with special needs.

4.3 Project complexity

Projects in our courses are relatively complex and students are supposed to spend up to 250 hours of intensive work to reach planned learning goals. The complexity of the project usually also affect its duration and the projects are organized over one or two semesters. Students proceed through six phases of SADDIE model. In each phase there is a need for intensive interaction between all groups' members, between lecturers and students, and less often between different groups.

Interaction requirements depend on information richness required by particular activities and play an important role in the design of collaborative learning environment (Rugelj, 2000).

Activities requiring groups to generate ideas are on the low richness end. They only require transmission of specific ideas; emotional and evaluative connotations about message and source are not required and are even considered to be a hindrance. Intellective problems (i.e. problems “to choose”) consider situations where a single correct answer or preferred solution exists. Situation is uncertain or ambiguous when a given group or its members have limited information available about the situation at a given time, but that missing information could be obtained. Activities requiring groups to solve intellective problems lie in between two extremes, on the low richness end. Tasks of the type “to judge” are characteristic for situations that are equivocal, e.g. they can be viewed from more than one perspective and can be taken to have more than one meaning. It is obvious that these activities lie on the high richness end. Negotiations and conflicts resolving activities require transmission of maximally rich information, including not only facts, but also values, attitudes, affective messages, expectations, and commitments.

4.4 Communication media

In principle, communication media represent a bottleneck for information exchange in any collaboration on distance. Even the best tools for communication support can hardly deal with the amount of information that is adequate to performances of human sense organs. It is evident that the characteristics of communication channels between members of a group have a strong impact on the quality of collaborative work. It is not difficult to measure the throughput of a particular communications medium technically, but there is no simple relation between the measured throughput and the efficiency of group work. Particular activities differ substantially as regards information richness. The richer is particular task, the higher throughput of communication channels is required and the more efficiency degradation results from the throughput limitations.

As our students participated in traditional classroom learning activities, group members had many opportunities to meet face-to-face daily. Therefore, the most delicate tasks were organized face-to-face and only less intensive interactions took place in the communication support systems, such as forums, chats, or wikis, of the learning management system. In some cases students also used videoconferencing system, telecommunication applications on the Internet (e.g. WhatsApp or Skype), and mobile phones. E-mail was used more coordination and synchronization tasks.

Characteristic communication patterns for collaboration in a group are one-to- many and many-to-many. It is well known that these patterns are not well supported as one-to- one communication pattern is prevailing. Most important activities that need special support are small group discussion, peer counselling, team presentations, shared document repository, and group authoring tools (Rugelj, 2000).

We will consider the cases where members of a group for different reasons can't meet face- to-face and work is carried out by the support of different communication support systems. Small group discussions can be successfully implemented in forums that represent widely available collaboration tool for one-to- many and many-to-many communication pattern. If the students want to accelerate and intensify their collaboration, they can participate in »a virtual group meeting« and synchronous tools for collaboration, like chat, can be used. The problem is relatively low information throughput of these tools. Video conferencing tools that allow much higher throughput represent a good alternative, which is now widely available.

Shared document repositories and group authoring tools can be implemented in many different ways. Students mainly use different solutions in a cloud to store data and for authoring, while wikis are still very popular for joint authoring.

5. Inter-group and external interactions

In all observed courses there was practically no inter-group interaction, although we strongly encouraged it. We expected that in problem based learning students could benefit from sharing knowledge and information. Competition between groups that represented an important motivational factor hindered collaboration and knowledge sharing. To overcome this problem, lecturers and teaching assistants consciously encouraged groups to present their solutions to specific difficult problems in regular weekly meetings where students reported on the results of their work in the project in the past week to lecturer and all other groups.

External interactions refer to interactions outside the group. Students interacted most intensively with the lecturer and with teaching assistants. As we have already mentioned, lecturer gave feedback to students' activities and their results regularly, in weekly meetings. Feedback was related to all strategic decisions of the groups as well as to some critical individual specific solutions. Teaching assistants mainly supported technical aspects of game design and production, associated to use of game machine or game development environments. Another field, where students got special support was graphical design.

In few special cases, where some serious problems appear with game machine, students were also encouraged to communicate with experts at the Universidad Complutense de Madrid, who developed game machine. Another external sources of information were some specialized forums where game developers discuss their problems and suggest solutions and some serious game design web portals such as SEGAN (http://seriousgamesnet.eu), where different resources for game design are available.

6. Conclusions

Project based learning is an instructional approach that, in contrast to conventional education, transfers control over the learning process from a teacher to students. Students are encouraged to formulate and then follow their own learning objectives and to select the resources and tools that best suit their needs. The lecturer's role is to provide a range of resources that the students, working in groups on real-world problem, can access, and to provide feedback. Collaborative learning is a key part of a project based learning approach. Serious game design represents an appropriate subject matter for project work, because its complexity is suitable for such approach and for group work. Project work was organised in the framework of the SADDIE model (Zapušek & Rugelj, 2014) that comprises all key stages for the specification, design and production of serious games (Rugelj, 2015). We conducted a case study, using results which have been collected in the last five years when we carried out our project based learning activities in the framework of several courses at the Faculty of Education of the University of Ljubljana and at the Department of Informatics of the University of Rijeka. We analysed how working groups form, how members of a group organized their project activities, and how they communicated in a group. We also investigated how group size and its heterogeneity, complexity of a project, and characteristics of communication media influenced interactions in a group and what were the characteristics of interactions of a group with other groups in a course and with external experts and resources. The results of the analysis will help us to understand better the processes in groups during project based learning and to improve the efficiency of learning in our courses, which are based on the constructivist approach.

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Games for Exciting and Effective Learning[1]

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Abstract: Nowadays as the world moves towards a knowledge-driven economy, education is becoming the one of the most significant economic topics. Russian education is falling substantially behind in this movement, as its education system does not adequately enough address humanistic tasks and missions. In this article we intend to identify, firstly, resources available to the education system and, secondly, we estimate its overall effectiveness. We will offer examples of strong dissatisfaction with the learning environment and its results by different categories of students and parents. We will identify the main reasons for the relatively low effectiveness of education in Russia. We will substantiate a set of new principles for creating a more comfortable and effective educational environment that balances opportunities for students with different educational backgrounds and delivers better results. We will present applied methods we have developed in order to raise student success rates: (a) a system of educational games that provide strong basic frameworks to solidify and add to new knowledge related to multiple social-cultural areas. In Russia game-based learning is used extremely rarely, and there has been very little research in this area; (b) a system of reflective survey methods for development of social thinking and raising student awareness of their opportunities and resources in the context of the knowledge they gain; (c) "life for education" - different pieces of various materials related to students' social reality are used for manipulating and understanding.

Keywords: new learning principles; system of learning games; student as the starting point of education; spatial, time and social coordinates for knowing/learning; effective and comfortable educational environment; reflective research/learning technology

1. Introduction

Much effort in contemporary economies is directed to the search for highest quality human resources and a vigorous hunt for talent. Russia claims similar global perspectives: go to the knowledge economy, developing human resources, become a world leader in education, etc. This is seen in Russia's documents titled Concept of long-term social and economic development until 2020 (published in 2008) and The State Program development of Education 2013-2020 (published in 2012). Unfortunately its related activities mostly consist of a number of ambitious statements. The education system in Russia is shaken by new and ongoing reforms, and recent Russian reformation of education is connected mostly with efforts to standardize the learning process and to fight for quality control in education.

In spite of continuous reformation, ratings of Russian educational institutions globally are falling. Russia's ranking in the Programme for International Student Assessment (PISA) has decreased from 29, 24, and 28 in 2003, to 34, 37, and 41 in 2012 – respectively math, science, and reading (PISA 2014). In the IMD World Talent Report of 2014, Russia ranked 55 - 2011, and 54, 56, 53 – in 2014. In 2006, Russia started in the rating at 42 (IMD 2014). The rating of the Moscow State University - the single Russian university included in the top 400 best worldwide higher education institutions - in 2015 fell to 196 (World University Ranking 2014-2015). The deterioration of Russian education and science is inevitably also due to the thousands of well educated people who have left the country over the past decade.

Different ongoing permanent reforms of education do not address the essence of learning itself, the teaching methods or the subject matter of disciplines. Ken Robinson, an internationally recognized leader in education, stated in a TED talk: "Every education system in the world is being reformed at the moment and it's not enough. Reform is no use anymore, because that's simply improving a broken model. What we need - and the word's been used many times in the past few days - is not evolution, but a revolution in education. This has to

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be transformed into something else" (Robinson 2010). This assessment is fully applicable to the current state of Russian education.

The cumulative educational results of the ongoing Russian initiatives have not been studied and estimated, and have been never publicly discussed. According to recent surveys, more than 40% of respondents are not satisfied with the current education in Russia.

The first task of our analysis is to estimate drawbacks of the existing systems of education.

We intend to reason that considerable resources may usefully be invested in order to improve the content of learning materials, the principles of teaching, and creation of a more comfortable and effective educational environment overall. It would also be advisable to include students as partners in the educational process.

The components provide the substantiation of our approach:

In the Analysis (2):

- To identify the main resources of the education system and to estimate the overall efficiency with which they are currently used;
- To determine major factors of the inefficiency of the general model of learning and the negative consequences for students (absence of social thinking, primitive ideas about the modern world, countries and peoples, and how this is related to drop-outs, suicides, bullying, etc.);
- To discover reasons for the low efficiency of education systems

In the Practical Recommendations (3):

- To offer new principles for effective learning;
- To present the new applied methods and technologies this will be useful and effective for all students regardless of their social status and background.

2. The analysis of educational environment

In our research we analyzed various important different aspects of the modern Russian education. Below we present two: the types and the amount of resources available to the education system are named below, then, their overall efficiency is assessed.

2.1 Resources of the education system in Russia

We intend to pay special attention to two types of significant resources:

- A high number of motivated stakeholders (schoolchildren and their parents) in their first steps in education. We consider them it as the most important resource of the education system.
- A large amount of time resources. As an example the education process in Russia takes 10, 15 and even 18 years, this involves a very significant amount of vital time from each student. The expenditure of such a high level of time resources should make it possible for most students to reach not average, but outstanding, even magnificent, results.

There are also many other resources, such as Premises/Territories, Staff/Professionals, other material and financial resources, support from different foundations, and more.

2.2 Unsatisfactory results of education

In spite of spending huge resources, global education systems do not provide rather strong results, similarly to Russia. Millions of students drop out of schools and colleges, receive poor educations, and thus do not reach their professional or social potentials. They may not build the necessary skills to achieve their goals and, as a consequence, many of them enlarge the masses of unsatisfied, frustrated, and aggressive people.

Some statistical facts. It is well known that about 1 million school students annually leave high school in the USA. Russia does not provide any reliable statistics in this regard. According to UNESCO data 57 million children are out-of-school globally (Education For All. Global Monitoring Report 2000-2015). Russia is one of the leading countries on child suicides and drug abuse among children. Russia has an enormous juvenile prison population (about 40 000 inmates, or 3% of all prisoners). Most of these outcomes are produced or exacerbated to a certain extent by non-optimal teaching and educational environments.

Some notes from our surveys. We have a great deal of evidence from a large number of our reflective research on students' satisfaction with their own education. We have conducted approximately 20-25 research projects related to education, with the support of various grants. We mostly use open-ended questions in our questionnaires. Our respondents were schoolchildren of different grades, from elite and public schools in St.-Petersburg city and regions; students from professional colleges and the best St.-Petersburg technical and humanitarian universities, among others. We can present here a number of convincing results related to students' low satisfaction levels with the learning environments they encountered.

(a) One research project contained the following task for students:

"What tasks do you like (or don't like) to do and what tasks do you do (or don't do)?" The answers related to "I don't like (it), but I do (it)" were: "Go to school and do homework» given by 60 among 69 students of 9th grade.

(b) In another survey, 289 respondents submitted the following results:

On the question "Which aspects in your school are unsatisfactory for you?" respondents wrote 151 text messages, distributed into 6 thematic groups:

54% - School/learning are not pleasant at all;
14% - Learning is too much hard work. There are too many lessons/ too much homework;
12% - Stress, tension, offenses, fears;
10% - Laziness to go to school, to do homework;
8% - Boredom;
2% - Loading our brains with unnecessary things useless for the future.

We would like to highlight complaints of school students and their parents in two main aspects: high learning workloads and low quality of learning, which is just above all controlled education system

The answers of school students to a question "What would you like to change in school learning?" The answers were as follows (percentage of respondents):

26% - to change the nature of teaching;
21% - to increase sport activities;
17% - to involve more art activities (music, dances, painting);
11% - to have more IT-courses

We offer two groups of students' notes related to the idea "to change the nature of teaching":

- ***Wishes for more interesting study***: "I want additional classes, entertaining and instructive"; "To receive interesting tasks", "Interesting subjects", "The practical training", "More interesting teachers", "Interest and hobby", "Homework has to be interesting", "Competitions", "More interesting competitions in learning", etc.
- ***Wish to learn with games*****:** "Interest in games", "More gaming practice", "More learning games", "More fascinating games", "To read less – to play more", etc.

(c) The results of our different research projects testify that study/school appears to be the most uncomfortable environment for students in their daily lives. This is the area in which the highest stated dissatisfaction is evident, with a percentage of students even attributing nearly 100% of all their negative feelings to school. Many students dream of reducing school time to a minimum in the structure of their total activity. One 6th grade boy wrote: "*The school of future this is when schools do not exist at all".*

We think that much of the negative social collisions in society are generated by the irrelevant, unsuccessful education and depressing learning/teaching environment.

(d) The results of the survey circulated in the four top technical universities in St.-Petersburg show a considerable volume of critical judgments, and dissatisfaction of students with different aspects of their educational process – lack of important courses and a surplus of irrelevant courses (Saganenko et al., 2013).

Education systems face additional challenges meeting the needs of children from weak or dysfunctional families who often do not receive a solid preliminary base for learning. These children need other forms of comfortable and friendly learning environments, like games for mathematics, reading, writing, and speaking.

The frequency and seriousness of these situations shows the demand for changes in the general situation in teaching and learning in the Russian education system.

2.3 The reasons for low efficiency of education systems

We identify one of the important factors of low success rates for different students as the serious scarcity of *actual social reality* in teaching and materials.

The 5th World Innovation Summit on Education (WISE) in Doha (Qatar) 2013 defined two main topics for discussion: "Reinventing Education for Life" and "Bringing Learning to Life," which had various correspondences with our idea of social reality in education. At that WISE summit, Hans Rosling also gave an interesting and relevant report "Bringing Education Data to Life" (Rosling, 2013).

The modern Russian education system is rigidly focused on standardization and control, is neglecting the development of vital creativity and independence, and, unfortunately for the Russian education system, the actual social reality plays no part in education.

Involving social reality in the educational process offers opportunities for every student to gain greater understanding and knowledge in relation to his/her life.

We offer evidence of the absence of social reality using an example analysis of three different textbooks (Saganenko, 2011) and materials of the Unified State Examinations (USE) on Geography in Russian schools for 2011, 2012 and 2015 (publication in progress).

Textbooks

- We will begin with the textbook for lower grades (3-5) on the culture and history of the St. Petersburg region "Pages of the Life of Our Region from the Ancient Times to the Present Day" (Ermolaeva et al, 2008). This textbook ends the description with the period of restoration of the city and region after World War II, which is very far from the younger school students. There is a too large distance in 65 years to modern children in 2010-2015. Much time and energy is spent to inform children about the past, but nothing to help them to understand the age in which they live.
- The second textbook is "The Social Sciences" (Bogoliubov et al, 2010) for the 6th grade. This textbook contains information about a number of well-known personalities starting with Tsar Ivan III (1440-1505). The most contemporary personality in this textbook is Andrey Sakharov (1921-1989). So, the last 25 years are absent in learning.
- The third textbook "The Cultural Study" (Bolshakov et al, 2010) is for university students. Here the description finishes in the first third of the 20th century with the period of Russian Emigration after the October Revolution of 1917. However there is no information on modern Russian culture.

So, none of the learning material we have tried to analyze include modern social reality, although there is a splendid multiplicity of exciting reality. Students are familiar with it thanks to modern TV, Internet, gadgets, exhibitions, etc. It seems that it is only the Russian education system that totally closes off the contemporary environment.

Examination materials

From 2009 to 2012, the Russian Ministry of Education rapidly introduced a new system of Russian education, based on standardization, quality control, testing and the Unified State Examination (USE), without any testing of new forms, evidential experiments, publication results, and discussion with professionals, the public, students, or parents. We have studied a great deal related to these innovations, but here we present only our examination of the content of USE geography tests and exercises.

As we develop different geographical games, connected with territories, we have a special interest in different teaching materials and textbooks on geography, and we took the USE material on geography for detailed analysis. We chose a rather definite type of the USE material - where different countries are compared on the basis of various social criteria. This analysis provides rather definite evidence of specific knowledge given by the USE.

One indicator becomes obvious at once – the geography has become absolutely unpopular at Russian schools among students. Low geography is chosen for examination by only 0-3 students per school/per year (while in the past, all students had examination on this discipline). The introduced formats of learning/teaching have evidently dampened the last gleams of student interest in Geography.

Our further task was to analyze various types of comparison of different countries using a certain indicator in the USE.

In the handbooks of 2011/2012 (they are equal to each other on the USE) there are 380 tasks mentioning 102 countries (**US**E-2011). In 2015 we found 242 tasks and 118 countries. In 2011, 2012 and 2015 completely coinciding subjects of tasks are offered.

The structure of subjects of the USE tasks 2011 is the following:

40% Demography, (to identify the country from 4 named which has a higher proportion of elderly / children / urban / rural population, etc.)
25% Geography (to identify correspondences of capital cities with states),
9% Politics (to identify the country with a similar political system),
8% Oil/gas production (to identify the country from 4 named, which has oil/gas production or is a member of OPEC),
8% Agriculture (to identify the country from 4 named, which grows a certain crop - rice or a sugar beet/cane, etc)
5% Natural resources (to identify the country from 4 named which owns and sells a certain natural resource - wood or aluminum, etc.)
1% Industrial development (only 5 tasks from 380 related to industrial development: 4 were related to automotive, 1 - to aircraft industry – to choose 1/3 with a certain industry from 4/6 countries named).

And, this set of spheres of national activity is represented by the USE tasks as a full specter totally covering modern geography and modern times for Russian students!

It is also interesting to examine how much attention in the USE is paid to different countries.

The number of mentions of different countries in 2011 in the USE tasks was the following:

- Most attention was paid to Canada - 62 times, India - 57, USA - 56, Brazil - 53, China - 47, Australia - 46, France - 40, Mexico - 37, Japan - 37, Germany - 33, Nigeria - 31, Algeria - 30 times, etc.
- An inexplicable number of mentions were received by: Mongolia-23, Bangladesh – 17, Angola-16, Afghanistan-16, the Republic of South Africa-16, Venezuela-15, Laos-12, Cambodia-10 times
- It is interesting how rarely other important countries were mentioned (only from 1 to 4 times): The Netherlands, Estonia, the United Arab Emirates, Saudi Arabia, Singapore, Israel, Ireland and Luxembourg. These omissions seem strange as the countries are former republics of the USSR or our neighbors, significant European states, or rapidly developing countries.
- Some of the countries that play important roles in today's world are not mentioned at all: Qatar, Bahrain, Hong Kong, Taiwan, and Singapore (absent in 2015).

Thus, some super-dynamically developing countries are absent from the USE material, while some less-important countries seem to appear unreasonably frequently.

The considerable amount of tasks presupposes very primitive comparison, for ex.:

- "Choose the country with the highest life expectancy: *Indonesia, Vietnam, Thailand, Japan?"*
- "Choose the country with a postindustrial economy: *Angola, Cambodia, Sudan, France".*

No exceptional skills are needed to choose Japan and France in these tasks. However, if students are not able to choose the right country, a reasonable question arises regarding what students are taught in 7 years of geography.

Overall, our analysis shows that approximately 50 % of the USE tasks do not require high-level knowledge and need only minimal erudition.

Modern students living in a megacity have to waste time and emotions on completing tasks on such a things (choosing 1 from 4 countries where rice or cotton or sugar, etc. is cultivated), but nothing about the relevant miracles of modern engineering, architecture, construction, etc. appear on the exams.

The analysis of almost any textbook uncovers many curious questions and doubtful details, outdated and strange facts, while a huge number of components and dimensions of the modern world including industry, architecture, information technologies, science, education, tourism, culture, sports, scientific and technical exhibitions, real estate, natural and cultural sights, aircraft and automotive engineering, etc. are absent in modern Russian education. As we stated above, social reality is extremely important for the learning/teaching process. These components and dimensions represent exciting examples of actual social reality and are interesting and relevant to students.

In addition, it is necessary to note that the content of textbooks and handbooks basically do not change from year to year (for ex., the USE boring indicators and tasks for 2011 and 2012 coincide completely, and in 2015, the situation does not change significantly).

However, the world is changing from year to year. Even demographical variables fluctuate in a short interval of time, which is excitingly presented by Hans Rosling in his talk on TED. There is a great deal of interesting and useful information on demographical dynamics the world set out in Internet (Rosling 2006).

It would be much more interesting for modern students to study things distributed worldwide, rather than the cheerless and static data which are offered in the majority of teaching/learning/examination material in the Russian education system.

2.3.1 The status of the student in the educational process

In addition to the absence of study of modern society, the life and environment of students is also not addressed in the Russian education process. Despite having studied for many years, students are not encouraged to explore their own potentials, values, or interests, and have little knowledge of existing resources of modern society and the world as a whole. They are left to build this knowledge themselves outside of school.

There is another significant issue - the students are not considered the partner of the educational process.

Schools rarely make use of the resources which the youth possesses nowadays. In comparison with the older generations, modern students have a broader outlook and often better understand the possibilities and character of the modern era. They possess more modern information and communication resources, and are also very familiar with the worlds of film, modern art, cultural and educational events, and have greater experience managing and interacting with modern resources, etc.

Modern students have got ability to access and interact with the contemporary world, however teaching is guided by the approaches of previous decades, and does not adequately consider shifts in the development of modern children.

Also, students have ideas and knowledge of a multiplicity of places, types of social activity, categories of people, etc. and are able to share social information. Students of mine are very often partners in my projects – they can collect data about different social cases in their environments, can prepare trial versions of studies of specific social problems, preparing the ground for a more solid stage for research on St.-Petersburg and other cities, from families with the different levels of prosperity, and they help me to collect the empirical data on different aspects of our projects. So, students should be considered as partners in educational and research processes.

3. Practical suggestions

In order to overcome some aspects of this generally unsatisfactory situation we present a number of our practical findings.

3.1 The new principles of successful learning

The leading principle of successful learning, we strongly believe, is as follows: all learning and accumulation of knowledge from the first steps must begin *from the point "the student" (a child/a teenager/a youth/an adult)*.

The next productive idea is to create a strong framework of elementary integrated knowledge at the most initial stage. In this statement there are three keys: to use *simple knowledge elements*, to build from these elements a *strong framework*, and *to start from the very beginning* of the educational path.

The first integral principle can be represented approached through the three main coordinates:

- *The Territorial/Spatial Coordinate* – it is necessary to start the teaching process by studying the student's consecutive territorial spaces, directly related to her/his own home, apartment or house, neighborhood, street, district, city, region, country, continent, world.

Using this approach, the complicated sequence of extending spaces significant to the student will be identified.

- *The Time Coordinate* – it is important to start the learning/teaching process from the present time (literally, to move from the reality of 2015, not from the époque of Paleolith, or from the first Russian governor, Rurik).

We have studied the content of a number of Russian learning/teaching materials and failed to find any current cases or situations related to modern reality. In order to support this, we developed some games where the objects are allocated alongside the timeline. We have some board games with the Governors of Russia, U.S.A. Presidents, etc. in progress.

- *The Social Coordinate* – it is important and effective to start studying social aspects of the world around with understanding of the student's own values and interests, her/his vital spheres, consistently moving to wider social horizons and understanding her/himself functioning in different social spaces.

For each coordinate offered we have developed different types of relevant learning/teaching methods and learning approaches in order to build solid bases for understanding of the proper sphere and to accumulate knowledge related to it.

3.2 Educational games

One type of applied resources is serious educational games on different subject matter. Playing these games creates a strong initial framework for studying specific informative blocks and further systematic accumulation of the subject knowledge.

Educational board games. The system of our educational board games is suitable for any age group, and provides participants with healthy leisure, pleasure, and a strong ground for building knowledge of a certain objective. The games provide strong applicable knowledge in the fields of history, culture and geography, etc. Below we present a list of our games related to different cultural and geographical areas significant for a student's development.

The list of games designed:

- ***"Europe"*. Its material includes a set of 45 cards, each with information on one of 45 European** countries. Each playing card contains a geographical map of the country, its flag, and two significant data (the size and population of the country and possible other variables).

More than 10 methods of playing with measurable outcomes have been developed. Often the goal of play is to collect as many qualitative points for each round as possible – each card won counts for 10 points.). Whatever country (biggest country in Europe is the European part of Russia or smallest one is Vatican) gives 10 points to a player and relevant points are added for a certain parameter of the each country won. The game set contains instructions explaining the rules for 10 modes of play in Russian and English. (www.igraevropa.ru**)**

- *"St. Petersburg"* (City sights, division into administrative districts, puzzles, etc.). *"Leningrad region"* (City sights, division into administrative districts, puzzles, etc.) There are different data as the Leningrad region consists of 16 districts with different sizes of territory and population, etc.
- *"Russian Federation"*. (Similar to "Europe." The game focuses on the administrative and political division of the Russian Federation, so cards contain a map for each region, its flag, and the size of its territory and population. It includes different options).
- *"History of the Russian State"* (Governors of Russia from Rurik to Putin with simple facts and several methods of play).
- *"The Globe" (*Hemispheres and their territorial fragments are used for different tasks)
- *"Painting Art through the Centuries and the Countries*" (Masterpieces of world art: set of artists, world museums, illustrations of paintings. Useful facts about artists)
- *"The European World Heritage of UNESCO" (*The game has been developed for European countries in relation to the UNESCO World heritage register)

A number of draft game models based on data related to continents, subways, airports, aircraft companies, railroads, the automotive industry, and more are in progress. For each complex object we find specific organic and relevant quantitative points, modes of play, and methods of counting the results. The majority of games are attached to a territory: to s set of the certain countries, continents, or to a certain place around the globe.

3.3 Reflective technology

This technology is built mostly on systems of open-ended questions, which is an effective new method for development of people's sociological thinking and it is also a tool to obtain qualitative and quantitative data about a changeable world or a certain situation. This technology is supported by all significant components: the detailed concept has been developed, the investigative potential of 15 types of open-ended questions has been identified and substantiated, 30-40 reflective research projects have been carried out, effective software to support this type of research has been developed, the tools for comparative classification of textual sets has been built, and a number of books and articles about the technology and research have been published (there is a good presentation in - Saganenko, Geger, Stepanova, 2011). The development of this integral project has been supported by different foundations. The reflective technology is applicable to social research as well as for education processes. This approach offers a tool for students to examine and understand better their lives in meaningful social contexts.

Because it does not rely on a standardized approach, demands creativity, and brings positive results, we can treat this method as a gaming technique.

In order to provide a better understanding of the scope of this reflective technique we present a list of examples of the research undertaken:

- *"Opportunities without limits".* 15 suggestions are offered, such as «If you had here [such a] resource, HOW would you use it and WHY?"
- 'Resources' include an offer for respondents to spend $5 000 and to explain *for what* and *why*; to choose a country to live in and to explain *which one* and *why*; to eliminate any social problem(s) in their life, their family, or their country and to explain *which one* and *why*, etc. This is an easy and attractive polling technique. This method is popular among children, students and adults of different ages. This survey method provides a great deal of interesting data and information for researchers.

- *Vital values.* The respondent is invited to identify 10 personally significant life values, to clarify her/his own meaning of each stated value and to evaluate its importance and satisfaction on a 100 point scale (Saganenko, Geger, and Stepanova, 2011).
- *My health and that of people around me*. This technique suggests examining the problem of personal health in the context of the adverse environment of modern Russian society.

Other topics and techniques have been developed.

3.4 "Life for education"

Different pieces of various materials related to students' social reality are used for manipulating and understanding. This creates quite a funny and unusual learning setting. We use different types of tasks on the basis of different printing production and other types of material.

For example, the discount flyers of the nearest supermarket are offered to children. The task for them is to buy products from the flyer for the sum of 100 or 500 rubles. Also a multiplicity of advertizing materials from a huge number of exhibitions, shops, agencies, etc (for example, real estates, medical and healthcare, travel services, shopping guides, magazines like Vertical World, The person Without Borders, etc.) have been used. Of course, it is possible to offer any fascinating tasks using maps of native country, native region, native city, etc.

Our main task is to make learning/teaching process more effective and inspiring and to leave space for students' own creative activity.

4. Conclusion

As a result of our suggestions we expect a number of fresh educational outcomes are possible:

- Different categories of students would feel more comfortable and confident in moving forward in their education;
- The numbers of creative people, talented students, and eventually talented professionals of higher qualification will increase;
- The number of student dropouts and other victims of education system will diminish; the optimal life experience for everyone will rise.

We also hope that the number of creative and unique solutions and projects will grow and increase the attractive and efficiency of the educational environment.

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Gamifying the Museum: Teaching for Games Based 'Informal' Learning

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Abstract: In this paper we present a study of master students working with the concept of gamification (Deterding et al., 2011; Bonenfant & Genvo, 2014; Sanchez, 2014) to design an informal learning activity in a natural history museum. The teaching unit was a project-based course covering fundamental concepts related to the use of games for educational purposes, and is part of the Information Architecture program at ENS of Lyon. The winter 2015 semester included one week of project work at the *Museum of Nature* in Sion, Switzerland. We present the course organization and pedagogical approach for the teaching unit. Based on observations, recordings and documentation of the students' process and products, we analyze the core concepts that became relevant in the students' game design for this informal learning setting. Specifically, we identify the notion of 'games as metaphors of the subject to be learned' (simulation), and 'games as spaces for reflexivity,' where players are prompted to assess their modes of thinking and behaving (feedback). We also discuss the extent to which this project aligned with the museum director's objectives of integrating a game-based learning activity in the permanent exhibition, with its collection of material objects, unique physical spaces, and use of multimodal resources. The exhibition had the narrative aim of highlighting the concept of *anthropocene.* This is a rather complex theme dealing with environmental changes and humanity's influence on the emergence of a new geological epoch. We analyze the ways in which the students integrated perspectives on informal learning with principles of gamification to engage their target audience in understanding the concept of *anthropocene*: young people (12-15 years old) on school field trips. We conclude by discussing the implications of this study for teaching game based informal learning in higher education programs, and we reflect on potential tensions and values of integrating games in learning activities in museums that became apparent from this study.

Keywords: museum learning, gamification, teaching gbl, design

1. Introduction

Museums are considered ideal environments for experimenting with informal learning technologies (Pierroux et al., 2007), and a multitude of game based programs have been designed for different media, platforms, and visitor types in recent decades. Museum learning games frequently entail the use of mobile devices, with missions that guide families' explorations of collections through treasure hunting and mystery solving (Cabrera et al., 2005; Dini, Paternò, & Santoro, 2007) or tasks that scaffold students' problem-solving across school and museum contexts (Pierroux, Krange & Sem, 2011; Charitonos et al, 2012; Bakken & Pierroux, 2015). This article explores the ways in which gamifying aspects and principles are applicable in the design of learning technologies in museums, and the issues that emerge when designing game-like experiences for museum visits. What are the lessons learned from game based learning research in museums, and how may these be taught to future digital project specialists working with museum professionals? The context for investigating these questions is a project-based course in the Master of Information Architecture program.

In terms of game based learning for family visits, activities modeled on treasure hunts, mysteries, and puzzles are common in museums, as is the use of mobile devices to guide and facilitate the collecting of exhibition information to collaboratively solve tasks. A familiar approach is seen in the design of *Mystery at the Museum* at the Boston Museum of Science (Klopfer et al. 2005). Family members used handheld PCs to collect information using infrared tags in a collaborative problem solving activity. In a study of twenty parents and children playing the game, researchers found that the interdependence of roles structured group collaboration, and that many participants felt their role had made a unique and essential contribution. In science museums, principles of discovery and inquiry-based approaches increasingly inform the design of resources, games, and not least technologies and social media that aim to support 'learning through play' on family visits (Beale, 2011; Katz et al., 2011). In a series of experiments, Gutwill and Allen (2010) explored how exhibit designs and rules for collaboration deepened families' inquiry in science museums. They found that improving inquiry skills in a group fostered deeper group engagement in learning activities than in educator-led or control conditions. Key aspects identified for effective inquiry learning included the need for participation of all members in the group, opportunities for meta-reflection on the kinds of interpretations being made underway, and the authoritative use of expert knowledge, whether held by a group member or guide. Studies have shown that interfaces that do not support group social interaction and participation are one of the main reasons technologies 'fail' in museum settings (Pujol-Tost, 2011).

In studies of learning on museum field trips, the use of worksheets and other resources by teachers and museum educators has been shown to have positive effects (DeWitt & Storksdieck, 2008). At the same time, museum visits are valued precisely because they allow for interactions with exhibits and learning experiences that differ from those in school. In designing learning games that both engage and support inquiry across school and museum contexts, mobile social media, 'smartphone' technologies, and ubiquitous Internet access have been pivotal developments (Naismith et al., 2006; Tallon & Walker, 2008; Wishart and Triggs, 2010). However, finding a balance between guided and open activities, and structuring opportunities for social interaction and collaboration are important when designing mobile applications for informal learning settings (Pierroux, Krange & Sem, 2011). In a recent study of augmented reality games on mobile devices for zoo field trips, for example, students using the game were focused largely on staying 'on task,' spent less time looking at animals, and talked more about the game than the exhibits (Perry & Nellis, 2012). In this study and master course, the students were asked to reflect on how their design addressed issues in the museum learning research, This paper has three different purposes. (1) It aims at documenting the work carried out by four master degree students involved in the gamification of a school visit in a natural history museum. Which theoretical background did they apply for such a design objective? (2) We also discuss the implications of this study for teaching game based informal learning in higher education programs, and (3) we reflect on potential tensions and values of integrating games in learning activities in museums that became apparent from this study.

2. Context

2.1 A master degree course in information architecture

The students in the project were enrolled in a master degree program dedicated to Information Architecture. Information Architecture is defined as "the art and science of organizing and labeling web sites, intranets, online communities and software to support usability and findability" (Information Architecture Institute, 2013). In this specific case, a small group of students (2 women, 2 men, ranging from 22 to 30 years old) chose a project based learning course on 'games and gamification of learning contexts' as an elective course unit. This course ran over 12 weeks, with 10 hours student work per week. The teaching was organized with six weeks dedicated to online, asynchronous and collaborative work modules about the core concepts of game and gamification for learning and instruction. Five full days (i.e., the students did not have other course during this week) were allocated to a collaborative project on the gamification of a learning context. The task assigned to the students was to design a proof of concept for a game for the *Valais Nature Museum* in Sion, Switzerland, adapted to the museum director's objectives. At the start of the project week, the students were instructed to organize the division of labor, tasks, and management of the design work, and to document their work process underway. The teachers and museum staff were 'on call' during this time, and the teachers held debriefing sessions with the students every day. At the end of the week, the students presented their final gamification design to the staff of the museum and the local Sion museum authorities, and the students received immediate feedback on the design solution. Following the project work at the museum, the students spent five additional weeks designing a website[1], as a final report, and a logo (Fig. 1), to present the context, the methodology adopted, the game and the justification of the choices that they made from a theoretical point of view. This website served as the final report of the project, and was the main basis for assessment.

Figure 1: Logo of the game

[1] http://perso.ens-lyon.fr/ariane.faraldi/INF11/rapportPearlArbor/index.html

2.2 The museum's narrative

At the initiative of its newly hired director, the Valais Nature Museum in Sion has undertaken a shift from a traditional natural history museum focused mainly on displaying its collections, to a 'nature museum' focused on a strong message and a mission to educate visitors about one of the main challenges facing humanity in the 21st century: establishing a sustainable relationship between mankind and nature. As a result, the narrative presented in the permanent exhibition is complex: human beings are now living in a new geological epoch called anthropocene, during which humanity has begun to have a significant impact on the environment. Therefore, the behavior of people must change. In addition to educating visitors about the concept of anthropocene, the museum director was seeking innovative approaches to offering visitors engaging experiences and meaningful encounters with the museum's collections and exhibitions. Given this context, he considered the project objective of designing a game-based learning activity for the permanent exhibition a means of involving staff and authorities in a conversation about introducing innovative practices, and decided to host the students for their project week. Based on interviews with the museum's educators, young people 12-15 years old were chosen as a target audience, since this group is a key audience that is difficult to attract and engage – both on field trips and on family visits. The aim was to design a game-based learning activity for this age group that could be played in both contexts.

3. Methods

The approach to this study is based on an ethnographic methodology (Whithead, 2004). The participation of the two researchers (*authors*) involved planning the course and scaffolding the project work carried out by the students, allowing a holistic approach to the case study design. The aim was to observe how the group of four students collaborated to solve the design task, and to understand their perspectives on how to deal with the theoretical dimensions of game-based learning in a specific context. The data that we collected encompassed field notes from *in situ* observations of the students' interactions, use of tools, and collaborative processes; documentation of resources generated in project room at the museum site (Fig. 2); audio recordings of meetings between students and museum staff, including the director; student documents, presentations and productions (including the project website); and the students' online discussion forum throughout the course. One of the most important moments for this data collection was the daily student de-briefings with the researchers, during which they presented what they achieved that day, the methodology that they applied, the results achieved, the difficulties they faced, and the foreseen work. Another key moment was the final project presentation to the museum staff and local authorities for museums.

Figure 2: Students early brainstorming meeting

In the analysis of the data, we identified four themes from the course literature, instructions, and lectures that became relevant for the students in their work process and finished products: game as metaphor and narrative; meaning potential in museum exhibits; games as reflexive spaces; gamification and museum education. We describe these themes below, focusing on how they emerged and developed in the students' work, and were applied in the finished products. In the discussion, we also reflect on potential tensions and challenges that the student 'solutions' posed from the museum staff's perspectives.

4. Game as metaphor and narrative

The students were explicitly instructed to identify a metaphor that expressed the core message of the museum. In game based learning theory, 'metaphor' means that the gameplay is focused on the core characteristic of the reference situation or subject that is supposed to be learned by playing the game.

Games may also be seen as tropes (Sutton-Smith, 1997). The ideas expressed by the game are based on a metaphor that fosters the player's interpretation and helps him to build an imaginary world. The term metaphor refers to the idea that the game captures the essence of a situation, that there is a hidden meaning behind the game, and that this second level of meaning gives the game its power and ontological significance. Fabricatore (2000) used the expression "intrinsic metaphor" to describe how didactical content and the game activities are intrinsically interrelated. In this way, the game tells the player "important things through the transmission of functional information" (Ibid.).

Importantly, from a museum learning perspective, visitors' experiences and understandings of metaphors and narratives in games – but also in the physical exhibitions – are constructed in the social context of the museum visit. Museums are *social* learning settings, and people typically visit museums in groups-families, friends, or classmates (Crowley, Pierroux & Knutson, 2014). As a result, the ways in which metaphors and narratives are made relevant in visitors' learning are deeply linked to both the previous knowledge of individual group members, but also to the conversations in which they share and elaborate on this knowledge. There are often large gaps between, on the one hand, the narratives told in an exhibition by experts and curators, and on the other hand, visitors' non-specialist knowledge or perhaps contrary narratives and experiences (Bauer & Pierroux, 2014). In terms of design principles for informal learning games in museums, then, this suggests that while simulations and metaphors may effectively reference experts' (or designers') perspectives and knowledge, it is nonetheless important to incorporate opportunities for visitors' own voices and reflections on the narratives being told. Wertsch (2002) calls this the *dialogic* function of narrative, or opportunities for visitors to 'make meaning their own.'

4.1 Identifying the metaphor

Taking into account these theoretical considerations, one of the first tasks accomplished by the students was to identify a metaphor linked to the narrative embedded into the museum exhibitions that they wanted visitors to explore through gamification. Following a guided tour by the director throughout the museum, the students held a brainstorming session to explore ways of distilling some core ideas. They then conducted an interview with the museum director to get feedback on the ideas generated. This process produced different ideas and suggestions, but the students decided that the most important concept was that of *anthropocene*: human beings are now living in a new geological epoch during which humanity has begun to have a significant impact on the environment. In the museum exhibits, this narrative is implicitly expressed by means of moving through exhibit spaces that stage different kinds of animals in progressive stages of domestication by man, from living in the wild, to being bred and used on farms, to captivity in zoos, and ultimately the extinction of certain species (Fig. 3). Among the visualizations in the exhibit spaces is a tree theme, used to convey information about nature and evolutionary time. However, only the last rooms in the sequence of exhibits deal with the theme of anthropocene explicitly using texts, images, timelines, and other forms of visualization. The goal of the game design was now clearly established.

4.2 Applying the metaphor to gameplay design

The students called the game *Pearl Arbor*. The name comes from the Latin root *arbor* of the French word *arbre* (tree). The trailer of the game is displayed in the existing entrance space of the museum, where a large *Tree of Life* is projected on a wall. The trailer explains the objectives and the rules of the game. At this point, the visitors are organized into different teams. The multiplayer game employs mobile technologies and mixed reality (Milgram & Kishino, 1994), accessing content from the collection of the museum via digital tablets at different points in the gameplay. The overall game is planned to take one hour to complete, and entails two different gameplays.

Figure 3: Museum exhibition (picture extracted from the project website)

The students developed the concept of *anthropocene* as a double metaphor, and two different gameplays are incorporated in the overall activity to convey this duality. The first gameplay is a battle between teams of 3-4 players. Each team uses a digital tablet to collect resources from a digital representation of a "Tree of Life" and then "capture" animals on display in the museum. The tree resources give power to the animals, each of which has special powers and can be used to fight other teams of animals. A progress bar indicates the depletion of resources as the battle is conducted, and when the tree is close to dying, the captured animals escape. Accordingly, the first game is a metaphor of human behavior during *anthropocene*. Human activities have a significant global impact on the Earth's ecosystems, and negative impacts are due to the competition for resources for short terms objectives. The players experience the fun of battling animals using resources from the tree of life in a simulation that models the unreflective manner in which humans have historically exploited nature's resources. The end of this game offers an opportunity for reflection and teacher-led discussion among team players. In response to this behavior, the second part of the game is a metaphor of a new world where human beings change their way of interacting with nature. Each team solves tasks (e.g., puzzles and riddles) by interacting with the animals in new ways (Fig. 4). The success of the team has both a positive effect on its score and on the regeneration of resources for the *Tree of Life*. A final debriefing session is organized in the entrance space of the museum where the final state of the *Tree of Life* is visible. The debriefing consists of a discussion on the concept of *anthropocene* led by the museum educator.

The shift between the two gameplays is thus also a metaphor for the need to change human behavior to preserve the planet. Importantly, the design takes into account the social and cultural characteristics of gameplay for this age group, and the narrative aims of the exhibit expressed by the museum director. In sum, the analysis of the students' work shows how they applied a museum narrative in the design of a game metaphor and clear learning goal. Moreover, they created links between expert knowledge and the intended player experience through the game mechanics, which emphasized players' embodied actions in the physical and social context of a museum visit.

Figure 4: Wireframes of the game designed by students

5. Spatial and material aspects of museum exhibits

Museums are often reluctant to incorporate too much guidance and information in the form of texts and other resources in the exhibition space, relying instead on the interpretive cues embedded in the curation and arrangement of material objects. Ideally, from a museum perspective, deep engagement with narratives, cultural artefacts and material objects is key to visitors' meaning making and interpretative processes, as information is drawn from close observations and elaborated on in conversations that build on previous knowledge and shared experiences. This is a particularly relevant issue for the successful integration of digital information and learning game designs, as it is tempting to over-exploit the potential of multimodal content in museum interactives and applications. Too much information introduces problems related to cognitive load; creates tensions between themes, objects and texts; interrupts spatial orientation; and contributes to expert monologues rather than dialogical forms of interaction (Pujol-Tost, 2011).

This dimension has been taken into account for the game design by the students, who aimed to enrich encounters with the objects on display through specific types of interactions. The *Tree of life* displayed in the main room of the museum is the first representation encountered when entering the museum. The tree became a central element in the two games, used in a bar image that indicates progression within the game. The animals in the exhibits also play an important role in the two games. In the first game, interactions between visitors and the animals are limited to pictures taken by players (animals are "captured"). In the second game, interactions with the animals consist of solving riddles and answering questions that lead to a better understanding of their role within the local ecosystem.

From a technological point of view, different aspects were taken into account by the students to facilitate the interactions of visitors with the collection of the museum. A team of players shares a digital tablet to access to the information needed for the game at different points of gameplay. The digital tablets are connected to a network (WIFI and TCP/IP) and the teacher has access to the information displayed by on the tablet of each team as well as the players' locations. RFID readers are displayed in the museum for visitors to access relevant information linked with the collection using their tablets. Other technical aspects were considered in terms of interactions with the objects of the collection. During the first game, facial recognition software extracts features from the picture taken by the visitors of the animal on display, prompting the next interaction. In addition, the image of the *Tree of Life* in the entrance area evolves according to its 'level of energy', represented by different seasonal appearances.

Such choices were made with the aim of directing attention to the collection and introducing new types of interactions with the exhibits. The meaning of players' actions reinforces messages visually conveyed in the exhibition, i.e., animals are 'captured' or 'domesticated', and draws attention to the way humankind interacts with nature. Information was integrated into the gameplay in a meaningful and contextualized manner. These dimensions of *Pearl Arbor* illustrate how multimedia content may be designed in ways that are sensitive to problems of cognitive load, while offering new opportunities for meaning making as visitors interact with exhibitions.

6. Games as reflexive spaces

In formal learning settings, teaching is explicit and learning activities involve asking questions or solving problems. Within the context of 'informal learning' in a museum, the visitor is expected to act autonomously or with the guidance of a museum educator. Educational resources such as worksheets may be introduced, encouraging people to elaborate on previous knowledge and better understand the objectives of the museum through problem solving. Brousseau (1989) calls the appropriation of a problem *devolution*. Games facilitate problem devolution by offering players clear goals to be achieved, and introducing feedback so that players can assess the relevance of their decisions. As a consequence, the autonomy of the player results (1) from the freedom to perform according to her own understanding of the problem/situation rather than the expectations of the educator, and (2) from feedback provided by the game so that she can assess her mode of thinking and behaving. Games offer an assessment system (Gee & Shaffer, 2010) and a reflexive space (Sanchez, 2014a) that enable a new kind of phenomenological relation with the world mediated par digital technologies (Sanchez, 2014b).

Devolution has been taken into account through different features of the game design. On a broad level, the *Tree of Life* displays messages and invites visitors to enter the game: "Your mission is to fight the other team by exploiting the resources of *Pearl Arbor*: animals, special bonuses and especially the energy of the tree" (first game part) and "By exploiting my resources to domesticate the animals and to fight you have exhausted me. You cannot live in a world without a tree of life. If you want to survive you will have to help me to regenerate" (second game part). At a smaller scale, devolution is accomplished through the elementary objectives of the games, or game mechanics, e.g., answering a question to get points. The game provides feedback on the digital tablets according to the decisions taken by the players. The state of the *Tree of Life* (its seasonal appearance) provides feedback for the entire group of players, while a system of earned points and a progression bar provides feedback at the team level.

Overall, analysis of the design of *Pearl Arbor* shows that the students were concerned with implementing types of feedback and guidance that both engaged visitors and enriched their interactions with exhibition narratives and objects in the collection in the museum. This was a theme in the literature and lectures as well, which presented studies of museum education using guided *vs* open tasks. The issue does not solely concern the amount of guidance that should be provided but also how to design spaces for reflexivity, where visitors freely choose which objects, exhibits and information they wish to explore. In terms of the game design, a key issue for the students was thus how to implement feedback that fostered players' reflections about the decisions that they made, while allowing for the potential to exercise autonomy.

7. Gamification and museum education

It is well documented that "learning occurs only after reflection and debriefing" (Garris, Ahlers, & Driskell, 2002). Game-based learning is effective if the player reflects on the play during a debriefing session. During this debriefing session, the educator is involved in leading a discussion about experiences gained with the game. In this way, the learning objectives become explicit. "The learner needs to learn […] how to think about the domain at a 'meta' level" (Gee, 2003). Brousseau (1998) termed this debriefing session *institutionalization*, stressing that it leads to the change of the status of knowledge. The situated knowledge needed to win the game becomes more universal and is validated by an official external source, the teacher/trainer.

The students took this dimension into account by incorporating a debriefing session in the main room of the museum where the "Tree of Life" is visible, and included a detailed description of the debriefing session sequence, grounded in a dialogical approach; the museum educator asks for opinions about the changes that occurred between game 1 and game 2, introduces the concept of *anthropocene*, organizes a brainstorming, collects words and ideas from the visitors in a digital tablet, and leads a discussion about the ways of classifying the different concepts. After the players leave the museum, they receive an interactive album by email that includes the photos taken by the players and additional information related to *anthopocene*.

Focusing on the context of a field trip visit and interviews with the museum educators about existing practices, the students paid close attention to the design of the debriefing session. Indeed, in this case, the aim was for knowledge to be made explicit for the visitors. They carefully considered the role of educators in the debriefing session, as the interviews indicated that game-based approaches would be only acceptable for the museum if the educators continued to have responsibility for the school visits. Making them responsible for the debriefing session was thus seen as a way to emphasize their role as experts. However, the interview responses collected by the students also suggested that introducing a game dedicated to school visits was also viewed as a challenge to existing practices, in that the role of museum educators would be reduced because of time dedicated to 'play' and greater autonomy offered the visitor. As a result, the appropriation of the game would depend on the extent to which museum educators accepted remaining in the background while the students played.

8. Conclusion

The first lesson that we learned from this teaching experience relates to the students' use of theory in their approach to gamification. Rather than focusing on the use of game elements such as points or rewards in a mechanical way, their take on gamification emphasized selecting a metaphor for the museum situation and creating a reflexive space in which the nature and the meaning of interactions included aspects of both play and learning. We associate such an approach with *ludicization*. *Ludus*, the Latin root of ludicization, means both playful and learning activities. Moreover, the suffix "icization" does not mean that it is possible to "make" the game as suggested by the suffix "fication" in the word gamification, but points mainly to the possibility of transforming the situation. In this case, ludicization aimed to introduce new types of encounters with museum collections and narratives, changing the visitor experience in the museum in specific ways linked to a game-based approach. One dimension was the use of metaphoric devices to capture the core messages and concepts that the museum wanted to foster. Another dimension related to the design of *spaces for reflexivity,* and specific activities to make knowledge explicit, e.g., collaborative tasks and educator-led debriefing sessions. From a technical point of view, the use of mixed reality, mobile devices, and location-based technology aimed to link conceptual knowledge with embodied experiences in the museum space, or what Kapp (2012) calls "experiencing the concept" (p. 189).

The study also showed how master students benefited from design challenges in a real world setting, as potential tensions and different value perspectives were identified in discussions about existing education practices in the museum. Ludicization fosters a different logic of engagement than visits guided by museum educators, and the 'game designers' solution broke with both the institution's established narrative design and the types of social (peer group) interactions that are encouraged on school visits. The students were attentive to these potential tensions and developed creative responses that the museum staff acknowledged as innovative and inspiring. The lesson to be learned is that tensions may emerge in real world design processes between the need for authoritative museum narratives based on expert knowledge and perspectives and game narratives that invite new – and perhaps counter-intuitive – frames of engagement and activities. Participatory design approaches involving museum educators, game designers and visitors have proven successful in fostering dialogues about how to effectively balance these different needs and perspectives (Pierroux & Ludvigsen, 2013). In this case, the students chose to address this concern by assigning museum educators the role of leading discussions in de-briefing sessions, referencing studies showing that introducing expertise is crucial to fostering links and closing gaps between the gameplay experience and the knowledge domain..

From a teaching perspective, in addition to assigning a game design challenge that was tightly framed and scaffolded, the educational setting for applying principles of gamification posed a complex set of loosely framed problems for the students. In terms of framing computer game design challenges for undergraduate students, Larsen & Majgaard (2014) developed guidelines for creating an expanded design space that emphasized "problem-based creativity" and cultivating students' identities as game designers. Their notion of game design space encompassed establishing clear goals and design assignments, formulating the intended player experience, and deciding the game mechanics – or actions that players can take. In this study, the students worked with a similar game design space that also involved generating ideas, paper prototypes, and playtest sessions. However, the brief timeframe prohibited the iterative development and testing of prototypes with museum visitors. Instead, the teaching approach emphasized working with design problems related to the material and ideational qualities of museum exhibits, the institution's needs and educational practices, and how contextualized (digital) layers of gameplay may impact young visitors' engagement, interpretations and experiences. Furthermore, the combination of expertise of two reseachers with different backgrounds was useful in scaffolding the students' work with a complex challenge that entailed taking into account theoretical concepts from different fields in the learning sciences (games and museums) and implementing project management and user centered design. As a first collaboration, we found that this interdisciplinary model for teaching game-based informal learning was productive. The participants involved – students, museum staff, and teachers – found this approach meaningful and effective, and the students incorporated perspectives from the multiple disciplines in their design solution. This model will serve as the basis for a new interdisciplinary course in spring 2016 and a different university partnership.

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Fabrication of Games and Learning: A Purposive Game Production

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Abstract: The concept of Game based learning has proven to have many possibilities for supporting better learning outcomes, when using educational or commercial games in the classroom. However, there is also a great potential in using game development as a motivator in several other kinds of learning scenarios. Using game development as an approach for including game based learning in various educations has become more accessible due to more user friendly game development tools and systems. This study will thus focus on an exploration on how game development motivates students and what they learn when creating games. We exemplify the potential of using game fabrication as a learning environment with the investigation of a game production, which involved over 25 students across semesters. In order to investigate students' experiences during this purposive game production, we set up an experiment where students were "hired" to work in a virtual game development company. Students then had to produce a game concerning global warming during their 2.5 months semester project. The main results indicated that students who worked on the purposive game production acquired several new technical and analytical skills, they increased their skills in production management, and they were more motivated to continue their studies after the production. The findings illustrate that there are great potentials in harnessing the power of game development in education. We conclude with a framework of best practice guidelines for other educators, who want to incorporate a purposive game production in their own activities.

Keywords: game based learning, game development, purposive game, problem based learning, production-oriented learning

1. Introduction

Using games as learning tools have been studied for several years, and the learning outcomes are often reported to be rather successful (Wang, 2010; Yang, 2012). Digital Game-Based Learning has furthermore shown the highest growth within higher education (Hwang, 2012). The motivational factor of using games has been proved to be a major part of the success, but at the same time the lack of student's motivation is still a big problem within university educations (Armstrong et al, 2013). We find that a major challenge would be to establish a teaching and learning environment which could use features from Digital Game-Based Learning and at the same time focus more on the motivational factors. One of our main questions is: how could a learning environment be established - based on Digital Game-Based Learning - promote the integration of learning specific topics, keep students' motivation and interests and at the same time be part of an existing curriculum? We see learning at its best when it is active, goal oriented, contextualized and interesting, and the teaching/learning environment should be interactive, provide ongoing feedback, sustain attention and have appropriate levels of challenge (Woo, 2014). This learning approach is reflected in Problem Based Learning (PBL) and project organized teamwork (Barge, 2010). Aalborg University applies PBL pedagogy in all its programs, which supports students' learning processes and an important feature of this model is that the motivational aspects is one of the basic elements. However, we have experienced that even when using the PBL model, students may lack motivation (Reng and Kofoed, 2012). Furthermore, we have found that students at Media Technology were very motivated, when they were developing or playing games (Reng and Schoenau-Fog, 2010). Therefore we decided to introduce a learning/teaching environment that would enhance students' motivation and at the same time give students the competences required in the study regulation (SICT, 2014). All technical programs at Aalborg University are based on PBL where each semester is divided between courses (15 ECTS) and problem based project work (15 ECTS). This is also the case for Media Technology where 100+ students study at each semester. At the later semesters, many students begin to consider if their competences are good enough to work in a company and we have the experience that a lot of students would like to work within the game industry after graduation. Therefore, designing a new learning/teaching environment closer to "the real world" led to rethinking the project work for the Media Technology fifth semester students. To meet these challenges a few teachers came up with a new concept for a game-based learning project, which was to let students develop a game in a virtual game company as a real production team.

In this paper we describe in detail the pedagogical ideas of the learning/teaching environment and the planning of a pilot project. Furthermore, we will describe the production process as well as the students learning and motivational process while producing the game. We then describe and analyse these learning outcomes and motivational intents during the project process, and conclude with a best practice framework to be used, when planning game-based-learning inspired problem-based, production-oriented project work.

2. Background

This study is founded on various pedagogical approaches and game based learning theories. In this chapter we will describe these further.

2.1 Pedagogical approach

In order to heighten students' motivation during their problem based project work as well as to provide the students with new knowledge and competences within game-production and project management, this paper contributes with a design-based learning approach founded on a production oriented game development when creating educational computer games. Previous projects on learning by design have especially provided successful results within technical and science areas (Ke, 2013). According to theories of problem-based learning and situated learning, design creates contextualized and authentic learning as design tasks force students to work in an environment which demands close to real life skills and domain knowledge when doing projects work. Developing knowledge and skills required in such situations are in addition more transferable to future situations (De Vries, 2006). Design-based learning using 'enactivism' which is a framework that argues for a close connection between affordance of a learning environment and a learner's capacity of action and perception in knowledge development (Lo, 2012) seems to fit to our pedagogical approach. Digital game development has been considered and examined as a "powerful learning environment" to stimulate active, autonomous learning via rich contexts and authentic tasks of composition and construction (Robertson, 2008). Educational game making, that requires content application, can be applied as a "micro-world" where designers or learners get to explore, represent and test their domain knowledge and skills and to integrate them into the game designed (Mitchell and Saundry, 2007). We find that design based learning in general and computer game development in particular is well connected with PBL and project work which will be the pedagogical approach for this case at 5th semester Media Technology. This approach has potential for using game fabrication as a motivational factor, while students gain knowledge from all aspects of game production. (See fig 1).

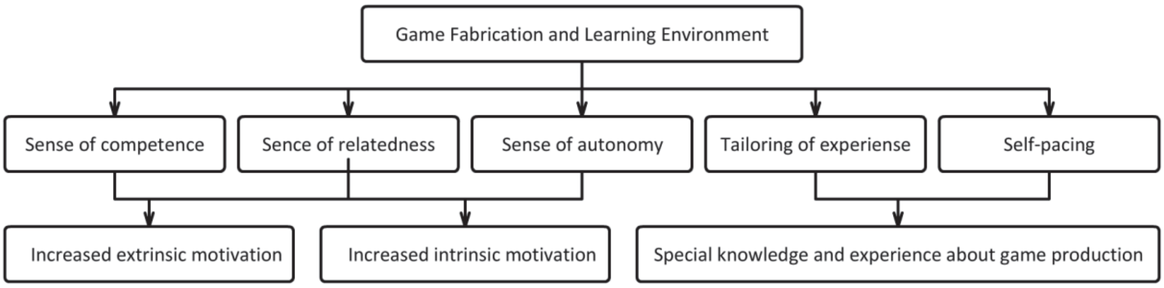

Figure 1: The pedagogical elements in the fabrication of games and learning production environment (inspired by Abeysekera and Dawson 2015)

2.2 The purposive game production – an experiment

The authors of this paper have in recent years greatly increased collaboration with both neighbouring universities and industry, in an effort to improve the quality of the Media Technology education. Through a close partnership with many national and international media companies we have learned about the composition and procedures of many of these companies' successful development teams. The idea behind the purposive game production was mainly motivated by the following three major issues: Students reaching the end of their bachelor education seem to have a growing concern about the transition from the skills and abilities they have learned during the education and the needs and requirements of the industry. It was clear that one of the most burning questions from the students to every invited speaker with an industry background was: "What do you expect from us when we apply for our first job, and do you think we have the qualification required by your company?" Another major issue was that the students did not feel that they ever had enough time to focus on a single skill/discipline in order to truly understand what is required to fully master it. Students were furthermore not easily convinced that our candidate educations do offer this depth while still holding a strong academic focus even though several successful student projects on both bachelor and master level have resulted in published peer-reviewed papers that were presented at international conferences in recent years.

In order to create a format that would allow both for full control of the production to the teacher, giving the students an experience as close as possible of to that of being in a company, and still staying within the requirements and rules of the current study plan - and a very limited time frame - we settled on the format described below (Fig 3). The students would have their semester split in two. First a three month period, in which the students would be part of the virtual company in the purposive game production. Second a one month academic project, where the students would be split in smaller 4-6 person project-group size, and use their product of the game production to develop and investigate an academic problem within the theme of their semester. Out of the approximately 100 students on the fifth semester we only needed 20 for the experiment. Each of the 20 roles for the production was carefully decided upon based on industry practice, the students' lack of experience, and the short timeframe of the production. Most of the European developing teams we interviewed are using some form of agile method, such as SCRUM, to manage and control their development. Therefore we quickly decided to use this structure (Schwaber, 2004). Most SCRUM models function with a project owner role being part of the company, but not part of the development team. The project owner is placed between the developing team and the customer and is setting up the requirements for the product. By giving ourselves these roles, we would have a full control over the production, but none of the daily management tasks which should be done by the students. It was very early agreed on that we should not select students based on skill level or previous grades. Instead we would allow all students to apply for the positions they felt most passionate about. Before the students went on their summer holiday, we informed them that they would receive an email with a job offer for our new virtual game development company. A few weeks later, we distributed an email where the students could apply for one of the positions in the game development team. The number of students, that both replied with a portfolio and accepted the contract where they promised to work fulltime, including following every lecture and course assignment, was exactly 20, and the distribution of roles was also almost exactly as desired, so every student could get their profession of choice.

A few weeks before the end of the summer holiday we started to receive a series of unusual emails. The students were asking if they could please be informed about the requirements of the purposive game production, because they wanted to skip the last weeks of their holiday, if we allowed them to start early. Based on the fact that they had to do a project more than the other students on the same semester, we agreed to give them a kick-off meeting 10 days before the official semester start.

The most important requirements for the game was:

- The game must be a meaningful, purposive game, build with the purpose to enhance teaching of a real, critical, and important topic in public schools (kids age 13-16).
- The game had to be 100% factual valid, and true to the latest research in the field.
- The game must give the young people an experience that would facilitate a fact-based discussion about the topic and its possible solutions in the classroom.
- The game had to meet a professional quality that would allow the students to use it when applying for a future job.
- The game had to be of a quality and integrity that would allow it to be used in our game-researchers' future work.

Directly caused by the short timeframe, we had to give the students a simplified timetable with only a few of the traditional phases of a game production. Since we knew the students were in unfamiliar waters in so many aspects compared to their traditional semester projects, it was decided to keep a fairly high amount of regularly spaced deadlines to ensure that mismanaged activities were detected early. (See figure 3).

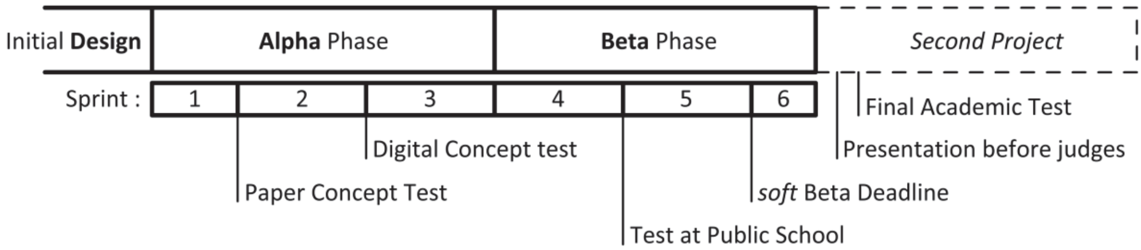

Figure 3: The purposive game production time table

To give another incentive to perform their best and meet the final deadline of the production, we called in a group of seven game company CEOs to judge the quality of the final product. Even though the quality of the finished production was not nearly as high as required for a professional production, several of the students were offered jobs by these companies in the weeks following the final product presentation.

The participants in the production were mainly students on the 5th semester at the Media Technology education at Aalborg University, Copenhagen. Furthermore, a few students from the Media Technology master education also joined the project. The production facilities were organized in a large project-group room at Aalborg University's campus in Copenhagen where the purposive game production team members organized their own area and divided it into sections based on their roles – for example programmers, 3D designers, 2D designers and production management. The game development tools which were used to develop the game were Unity 3D, a suite of Autodesk animation tools and various open source programs. The roles of the students in the team were as follows: Producer/production manager, production advisor, creative director, lead programmer, assistant programmer, lead designer, assistant designer, lead sound designer, assistant sound designer, 2D art lead, 2D artist, writer, lead game designer, game designer, 3D art lead, 3D artist, 3D modeller, 3D animator, creative designer.

The results of fabricating the game can for example be seen in a video, which describes the overall concept of the game (The Purposive Game Production, 2014).

3. Methods

We used an exploratory case-study approach (Stebbins, 2001) in combination with the descriptive, mixed-method case study (Stake, 1995; Yin, 2008) to investigate the students' experiences.

This examination explored the process of learning by design within the context of digital game development, project management and production. In particular this study addressed the following research questions:

- Did participating in a production of game development enhance motivation towards further studies and learning in general and in particular within Media Technology?
- How did the different aspects of the process of game production give knowledge and understanding of the various game development tasks?

3.1 Data collection

In order to acquire data from the production, we conducted a number of supervision meetings with the students during the semester, where we inquired them about their experiences. Furthermore, we distributed a survey to students at the end of the production phase where we asked them about their motivation level, before, during and after the production; learning outcomes and other questions related to their experiences. In order to verify the results of the survey, we conducted an interview with the whole team of students at the end of the production period.

4. Results

In the following, the results from the survey, observations and interviews will be presented.

4.1 Survey results

25 students participated in the survey. Four were female and 21 were male.

4.1.1 Motivation

The survey included a series of questions where the students were asked to rate their motivation or learning outcome compared to previous semesters (0 = Much less/None, 5 = Same, 10 = Much more/Very high).

It was clear that the students' anticipation was very high at the beginning of the project. This was expected for a new hyped production oriented style of project work. The challenge was to see if the students could keep their motivation throughout the project period. More importantly, we were curious to see if the new format would increase the students' motivation towards their next project and the education as a whole. The survey included a number of quantitative questions to support this investigation:

> *(Q1): "How high would you rate your motivation at the beginning of the project?" (AVG=8.64, STD=1.44)*
>
> *(Q2): "How high would you rate your motivation at the end of the ALPHA-phase of project?" (AVG=6.92, STD=1.85)*
>
> *(Q3): "How high would you rate your motivation right now? (End of Beta)" (AVG=5.44, STD=2.48)*
>
> *(Q4): "What is the possibility that you would join a production semester project in the future?" (AVG=8.36, STD=1.70)*

From the interviews it was clear that many of the students had worked harder than on any other projects before this. The SCRUM system with task lists, internal self-monitoring, and weekly presentation of work-effort graphs for all made it impossible to 'free-ride' unnoticed. With the new enlarged team size, communication and management became a much bigger issue. From both the weekly status presentations to the project owners and the interviews, the students clearly stated that they were surprised and somewhat demotivated by the effort it requires managing such a large team. The change in motivation through the phases of the project also clearly depicts the fatigue towards the end, as shown in figure 4 (Q1-Q3). However, when students were asked about their motivation to join another similar project in the future they were almost as motivated as in the beginning of the project. Even though they were asked when most fatigued (at the end of the production).

As stated earlier, one of the main goals of the format was to investigate that if students were introduced to the flexibilities and production oriented possibilities of the PBL based semester projects, it would increase their desire to continue studying and signup for one of the candidate studies. Questions (Q7 + Q8) in combination with the interview aims to clarify this point. As shown in figure 4, there is a clear indication that the motivation to continue the study indeed increased from Q7 to Q8. The standard deviations do however prevent us from claiming any statistical significant change in motivation.

> *(Q7): "How high would you rate your motivation to continue studying at Medialogy at the end of last semester?" (AVG=6.48, STD=1.92)*
>
> *(Q8): "How high would you rate your motivation to continue studying at Medialogy right now?"(AVG=7.92, STD=1.71)*

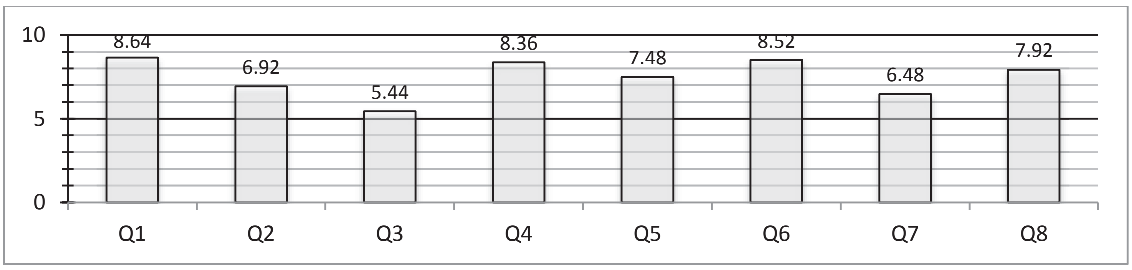

Figure 4: Study motivation and learning outcome. Questions Q1-Q8 described in the text.

4.1.2 Learning and skills

One of the clear benefits of a production oriented project format with clear roles is that it allows the students to get a much deeper focus on a single craft/skillset. Naturally there is also the negative effect that the students do not get any practice in the areas they did not select. We specifically selected the fifth semester for this experiment since it is so close to the candidate studies where students should select a discipline to focus on and master before applying for their first job.

(Q9): "How would you range your skills in [your own] role before the project launch (0-10)?" (AVG=4.44, STD=2.16)

(Q10): "How would you range your skills in that role [at the end of the production) (0-10)?" (AVG=7.21, STD=1.24)

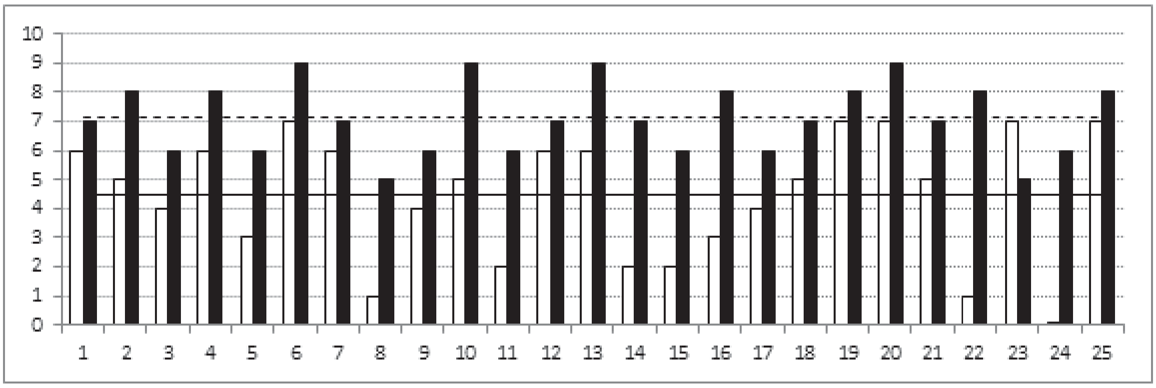

Figure 5: Learning and skills. Q9: Skills before (white bars). Q10: Skills after (black bars). Respondents 1-25.

When questioned on their perceived skill level before and after the production, the students in average rated that they had increased their skills in the chosen role by 60% (see Figure 5). Even when directly comparing the increased skill level to the increase of earlier semesters, there is a clear tendency that the students feel that they have increased their skills/crafts significantly with the new format (Q5).

(Q5): "How much do you feel you have improved your skills/crafts in this project, compared to earlier semester projects?" (AVG=7.48, STD=2.10)

During the supervision it became clear that the increased team size forced the students to abandon their usual simple managing technique, and search for a more stable and professional solution. The learning outcome in this area showed to be much higher than expected during the planning of this format, see Figure 4 and question (Q8). The new production format clearly gives the students a significantly higher perceived learning outcome than the traditional smaller PBL based semester projects.

(Q8): "How much do you feel you have learned about the challenges of managing a large production group in this project, compared to earlier projects?" (0=Much less, 5=Same, 10=Much more) (AVG=8.52, STD=1.33)

4.2 Focus groups results

25 students participated in the focus-group discussion, which was led by the authors. Four of the participants were female and 21 were male. The focus-group interview was semi-structured based on the interest we had to verify the survey results and to get more detailed answers on the reasons for students' responses. When the participants were asked to state one word, which summarized their experience they discussed among themselves and replied with the following words: A good learning experience, Hectic (in a positive way), Hard, Confusing/chaotic, Frustrating, Awesome, Fun and "a different, good concept". In the following the statements used when describing the choice of words will be presented in detail:

A good learning experience: Students stated that they learned a lot from the project. Especially new tools, skills, communication, production management, resource management, how to work in a company, about defining a target group, SCRUM, to use each other, the freedom to learn and do everything by themselves.

Everybody stated that they were motivated to work on a production like the purposive game production again. Half of the students stated that they learned more than in other semesters.

Hectic: Students stated that they had too high ambitions with the game, as their skills were not at the same level. The deadlines were not communicated clearly and there were many communication problems between the different sub-teams while the production lacked structure due to challenges with the management. Students used a lot of "all-nighters" on the project, where they kept working through the night. The leads also stated that having the task to lead the team is very time consuming. Finally, they also mentioned that they learned to listen to each other and to solve problems.

Hard: "Tough but good". Students had some challenges in understanding what the different roles were responsible for. It was hard to learn to be a lead and the role had a large responsibility, as stated in this response: "To give and to take responsibility". On the other hand assistants often did not have an overview of what to do. Leads often had to take over and it was also hard for them, when they should make sure that their study-colleagues worked hard enough. It was not possible to delimit the ambitions before it was too late. It was too much responsibility to be a lead and a scrum-master at the same time. It was also hard to follow the semester courses at the same time as the production.

Confusing: The organization of the production could be better, some students felt it was a chaotic production and they experienced "management hell". The structure was not set up from the start and SCRUM should be learned before the production. There were also communication problems in the beginning of the production and there were too many tasks at the same time. It was hard to take design decisions in the beginning and the production pipeline did not work in the start and people changed roles during the production. 25+ members of the production team were also too many, students reported.

Frustration: For most students it was frustrating that the final game did not end up as they wanted due to the high ambition with the game, and the low technical skill level of many team members, in the students' words: "The bar was too high". In the programming team, 4 were experienced programmers, while 4 were new to programming which made a too big difference

Awesome, fun and a different, good concept: Students stated that it was a good initiative due to the possibility to work with other semesters (the master students). They gained a more personal relation to other students on other semesters and got new friends from other interest groups, because within the large group, smaller teams formed based on their roles in the production. It was good to learn to work together. Students also felt they networked more and had a common goal to make something bigger, to finish something. While learning from other students, team members gained a lot of experience, which they thought would be valuable for them in the future. Students stated that they liked to have a lot of ownership of the production and that it was good that they were in charge themselves.

5. Conclusion

It can be concluded that the group-organised production-oriented problem-based project-work does have the flexibility and framework for establishing a learning/teaching environment which could enhance students' motivation for further studies and at the same time gain knowledge and experience within aspects of game production and management of larger productions. This approach supports students different interests within the different semesters study-regulations as well as it can give experiences very close to a real production situation.

The main findings of the survey, observations and interviews are that students learned a lot, and that the game-development based learning strategy seems rather efficient and demanding for the students. Their motivation to continue working on the production fell during the process, but increased towards the end. However they still wanted to work on another similar production and their motivations to continue their studies were higher at the end of the production. Students also experienced a lot of frustration due to the overwhelming challenge of managing a team of 25+ team-members, causing them to truly understand the importance of good project management. The students experienced that sufficient communication as well as planning and coordination of the game production as a whole as well as the team's collaborative production is very important, and that they had to be better equipped regarding those aspects. These reflections might be the best starting point for new learning processes – which furthermore was emphasized by the fact, that members of the jury committee offered jobs to the students. To the claim that it requires an extensive amount of knowledge to build a knowledge mediating purposive game, we witnessed that the students on their own initiative found it necessary to build their own wiki in order to structure their large amount of gathered research about climate change.

In summary we can conclude that the new learning environment together with the elements in our pedagogical model have given students increased motivation to continue their study as well as special knowledge and experience about game production.

The findings from the supervision, survey and interviews may now be used to summarize ideas on how future purposive productions can be organized better.

5.1 Best practise framework

The following best-practice framework is a summary of the experiences from the production, which may be used as inspiration for similar problem-based and production-oriented project-work (P^3) founded on design and game-based-learning.

- Maximum 15 persons per group, during the students first experience with P^3.
- Introduction course to production management tools and SCRUM, so that the team know what it is, before the production starts.
- The design should be decided on and fixed at an early stage.
- Roles and responsibilities should be clear.
- Students should be able to choose their own teams based on portfolios and early discussions.
- A good management tool is essential.
- Make sure all team-members maintain a high level of communication with other teams.
- Develop ideas across the different roles in the production.
- The Leads should have the power to decide (democracy is not always the solution).
- Project owners (supervisors) may help a lot by supervising closely and by setting clear goals, requirements and demands. It is essential that they make sure to give feedback often.
- Latest versions of the game ("builds") should be available all the time
- It is beneficial to work cross-semester, as the more experienced students can help and at the same time learn a lot.
- The group should meticulously evaluate each members skills before setting their ambitions.

In conclusion, the purposive game production experiment indicates that there is a lot of potential in using game fabrication and problem-based and production-oriented project-work as a learning environment. We will in future work focus more on improving the context of the productions in order to make it even more beneficial for students.

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Gender Differences in Perceiving Digital Game-Based Learning: Back to Square one?

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Abstract: Proponents of digital game-based learning, DGBL, often claim that since our children grow up with digital media, digital games are a medium they already know and have a positive relationship to. They say that this, along with several other reasons, such as the unique learning properties of digital games, are among the reasons DGBL is a relevant approach to educate current generations. Igniting children's interests in topics such as gaming and coding at an early age might thus spark their future interest in science and technology professions. At the same time, research indicates a difference in the gaming habits and preferences of girls and boys. In an ideal world, boys and girls would have the same opportunities. While the laws and regulations of most Western countries today support this ideal view, several things in our society indicate that gender equality is not yet accomplished. The different numbers of women vs men in science and technology is one of those indicators, as men still significantly outnumber women in such professions (Gansmo, 2011; Kafai, Heeter, Denner & Sun, 2008). We wondered why this is so - and how a balanced gender division in science and technology can be achieved. In this context, we set out to investigate the role of schools and other educational institutions and initiatives in Norway, in creating equally interested and skilled female and male scientists and technological professionals for the future. Furthermore, we turn the spotlight on to the experiences of young boys and girls who receive part of their education through DGBL. We wish to explore how they experience DGBL and whether there is a difference in this experience depending on the gender.

Keywords: gender differences, DGBL, equality

1. Introduction

The Norwegian Equality law states that women and men should have equal rights and be equally represented in all areas of the community (Likestillingsloven, 2013). In the past few years, we, the authors of this paper, have come to question the difference in gender representation in the areas that we teach and work with - IT and educational game design. We wondered where this difference between the males and females originates and how this might influence the future design of digital games for learning. In search for answers, we decided to look at how young males and females express themselves in relation to digital game-based learning (DGBL). What is the difference in the way young girls and boys perceive DGBL?

This paper is organized as follows: we first present and insight into previous research and theory. Then we describe the methods and introduce the data from Norway. We apply two kinds of data; gender statistics for recruitment to games- and IT-related studies and courses and focus group interviews with young learners. We analyse and discuss this data. Finally, the conclusions are presented. As this subject spans such a wide spectrum, yet our limits are fairly tight, we see this paper as an indicator for areas of further studies.

2. Theoretical framework

The issues regarding the educational potential of digital games and the issue of gender aspects in digital games industry have been increasingly discussed since the 1990s. While educational qualities of gaming environments have been well documented and widely acknowledged (Shaffer, 2006; Gee, 2007; Prensky, 2007; Whitton & Moseley, 2012) the gendered nature of the products developed by the gaming industry remains a matter of controversy (Prescott & McGurren, 2014). It is important to emphasize that different individuals may benefit from different approaches to learning. In connection to DGBL, Hainey et al. (2013) stress the importance of considering possible differences between pupils, including gender:

"If computer games are going to be a vehicle for learning in the future, then we must know more about what motivates people to play them and what particular people they are most suited for. It is also extremely useful in an educational context to understand cultural differences and gender differences to ascertain if computer games are not suited to particular groups because of such factors." (Hainey et al., 2013, p. 483)

Before proceeding any further, we wish to explain what we mean by "gender". Since our data is limited to the official binary division into two genders; male and female, we will employ this simple division. This is not to say that we are not aware of the complex nature of gender and sexuality, not necessarily bound to physically assigned sex (Foucault, 1981; Sumerau, Padavic & Schrock, 2015).

The problem of underrepresentation of females in the IT sector – and game design – is well evidenced (Gansmo, 2011; Kafai, Heeter, Denner & Sun, 2008; Campe, 2008). Not only are women underrepresented as game designers, but in recent years women designers have been subjects of harassment and hate propaganda, such as in the recent #gamergate controversy, in which female game designers and game critics came under unfair scrutiny (Dockterman, 2014; Ask & Svendsen, 2014).

At the same time as around 40% of all gamers are female (Kafai, Heeter, Denner & Sun, 2008), a study of a wide range of commercial digital games showed that over 85% of all characters are male. Moreover, the few females that did appear were more likely to be in secondary roles (Williams, Martins, Consalvo & Ivory, 2009). Those facts, as well as common assumptions about digital games being a male-oriented and male-dominated, make it extra important to emphasize gender neutrality when designing educational games (Kazimoglu, Kiernan, Bacon & MacKinnon, 2011). Some claim that by looking at which games are the most popular ones in a given culture, one will see reflections of the core values of the culture in question (Egenfield-Nielsen, Smith & Tosca, 2008). In this perspective, masculinization of game environments appears alarming.

A report from the Norwegian Media Authority in 2014, titled "Children and media" indicates that gender influences a variety of surprisingly different variables. For example, there are gender differences with regard to the numbers of players – 90% of girls vs 98% of boys, frequency of playing – 45% of boys report playing more than once each day as opposed to 30% of girls, games played – girls mention other titles and other genres than boys, with a few exceptions such as Minecraft, GTA and FIFA. Gender influences what kind of equipment is used for playing, how much the parents know about gaming and how many games with a (too) high age limit are played (Medietilsynet, 2014). Other research also suggests gender difference in both behavior and attitudes towards games. For instance, girls name a larger variety of games that they play in their free time, in spite of playing less in general than boys (Beavis, Muspratt & Thompson, 2014). In some cases females seem to employ and stress lacking digital media and game skills to assert their femininity (Thornham & Farlane, 2011). Steinkuehler (2010) draws to our attention a possible correlation between the fact that while boys seem to play more video games than girls they also seem more challenged in some aspects of school and education than girls.

Gender stereotyping has not proven successful in the commercial video game industry. The target customer is no longer a young, single male, but a wide range of individuals of all ages, genders, marital statuses etc. Furthermore, designing "girl games" has not always turned out well, as combining stereotypical gender roles with engaging game play can be hard and there is evidence that the gaming preferences of males and females overlap to a large extent (Lazzarro, 2008). Hoping to close this technological gender gap, several recent initiatives have focused on recruiting young girls to game coding courses and programs (Denner & Campe, 2008; Abdul-Matin, 2014; Cunningham, 2011).

3. Methods

The twofold empirical basis of the paper consists of recruitment figures for game- and technology related studies on one hand in several towns in Norway, focusing on gender distribution - and a total of 16 focus group interviews with 64 children and adolescents (ages 8, 11 and 16-18) on the other hand. The focus group interviews took place during the winter of 2014-2015. Interviewees were selected in cooperation with teachers and parents, aiming to adequately represent the pupil population. Two interviewers and three to five respondents were present in each interview. The interviews lasted for 20 minutes on average and were digitally recorded. The interviewers and three assistants transcribed the interviews.

A content analysis software (NVivo) was employed in order to find patterns of responses among the various gender and age groups. Further, we examined the gender differences through qualitative in depth analysis. The names presented in this paper are pseudonyms.

The original purpose of the interviews was to find out how young learners experience DGBL. Gender related topics were not included in the interview guide. Among the differences observed, were different gaming preferences between the genders. In this context it is important to keep in mind that games were merely discussed in the group interviews, so the titles mentioned only give us an idea about what titles seem to be trending. Furthermore, the numbers presented from the interviews only reflect how many happened to mention what, in each context. How many participants mentioned a particular game, for instance, was different between focus groups within the same age range and may therefore reflect the dynamics in each group as much as which games this age group is actually occupied with.

4. Analysis

Our analysis is divided into three sections. We start by presenting gender recruitment numbers. We then go on to examining the views of young Norwegians through content and lastly in depth analysis.

4.1 Recruitment

A Norwegian spinoff from Codeclub.org named Kodeklubben has since 2013 offered free classes for children who want to learn to program videogames. Recruitment first and foremost takes place through social media and traditional poster advertisements at schools. Using the "Scratch" system, developed in part by MIT, children obtain the opportunity to learn the fundamentals of programming. The long term goal of these classes is to encourage more young people to develop interest in programming and possibly a career in computer science, with a short term goal of letting them have fun while learning a new skill. These classes are free and mostly run by volunteers, consisting of students, teachers and computer science professionals. As of May 2015, such clubs have been set up at 57 different locations in Norway.

The attendance is voluntary, which indicates that the attendants sign up out of genuine interest in learning game programming. From a gender perspective, the starting attendance for the clubs is of interest. Figure 1 shows the distribution of attendance and gender in seven Norwegian towns.

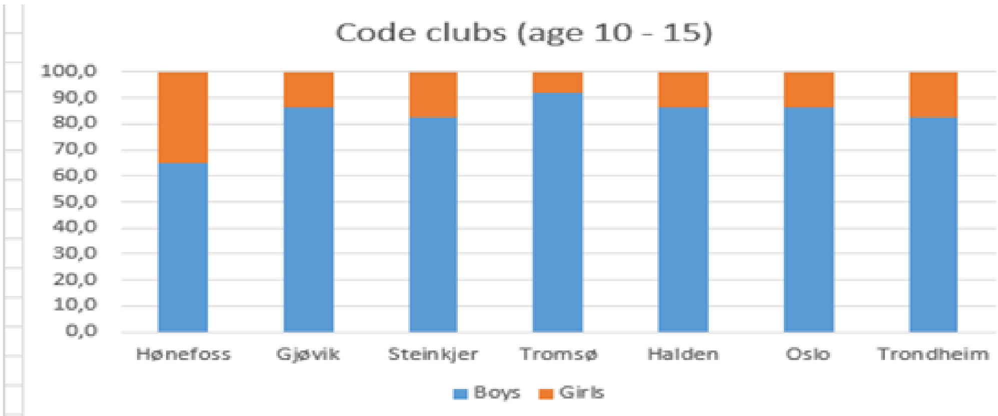

Figure 1: Gender and attendance at coding (programming) clubs in Norway

Each of the Code Clubs in Norway are autonomous organizations with their own set of rules on how to handle registration and attendance. Obtaining data about registration is quite accurate, whereas data regarding how many children finish the classes is harder to obtain, as information about "graduation" has rarely been stored. The only data about attendance obtained in advanced classes includes 20 boys but no girls.

Figure 2 shows the recruitment to IT studies at HiNT from 1990 until 2003 (approx. 40 students each year). The curriculum in this period included studies in Information technology, Informatics and Internet administration. The proportion of female students in game development studies at HiNT since the start of the program in 2009 has been relatively low, or around 10%. In the fall of 2014, 4 females started, as opposed to 42 males. After the first semester only 1 remained (and 40 males).

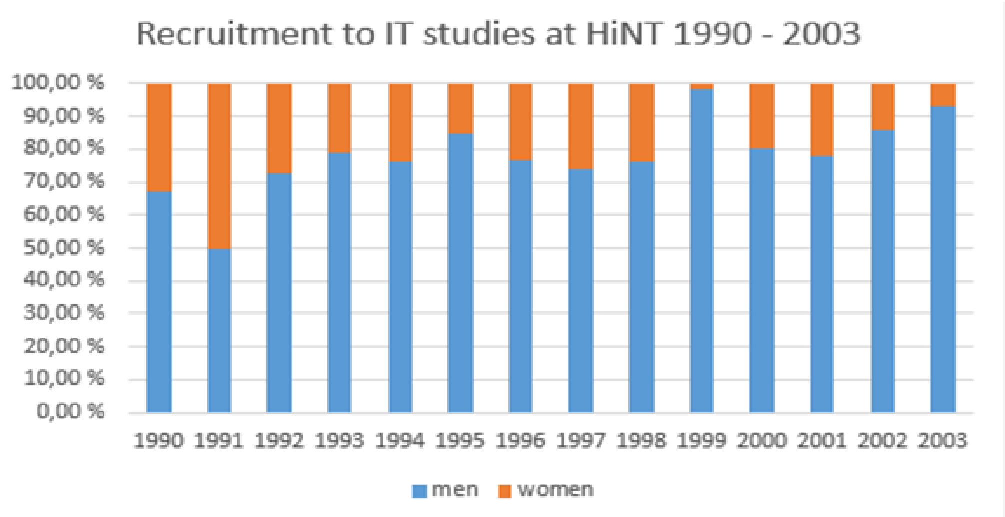

Figure 2: Gender and recruitment to IT studies at HiNT 1990-2003

4.2 Content analysis

To set the stage for the interview analysis, it is important to note that the focus group interviews did not specifically address gender. The questions were open questions about DGBL in school and the participants' own experiences thereof (table 1).

Table 1: Focus group interviews in primary and secondary schools

Focus group interviews				Transcribed interviews
	Boys	Girls	Total	Number of words
Age 8	12	7	19	13404
Age 11	6	7	13	8269
Age 16-18	19	13	32	23855
Total	37	27	64	45528

The content analysis provides an insight into how boys and girls in 3 different age groups talk about games in general, and educational games specifically. The software allows for group comparisons that may reveal patterns that are otherwise hard to detect by conventional coding of qualitative interviews.

Figure 3 shows the cluster analysis of word similarity based on the participants' statements. The highest correspondence of use of similar words is presented as parallel nodes in the tree structure. We note that the 16-18 year olds and the 8 year olds align more closely across gender than the 11 year old participants. We also note that the 11 year old boys align more closely with the older age group and the 11 year old girls align more closely with the younger age group.

The analysis next focuses on references to words relating to competition (n. konkur*) - and table 2 shows that except for the 11 year old girls - all the other age and gender groups refer to the concept of competition in some way. Table 2 also shows that the group with the most frequent references to the concept of competition is the 8 year old girls, with 9 references (45 %) to the concept - while among the other groups there are 2, 3 or 4 references to the concept of competition.

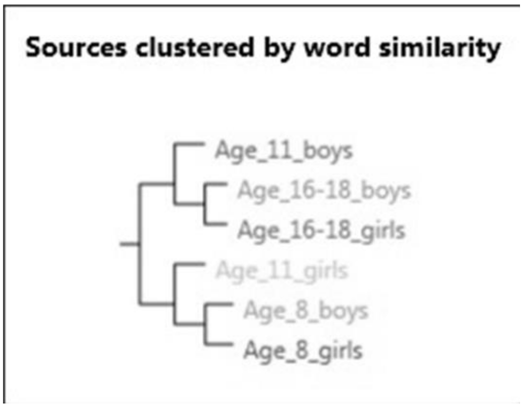

Figure 3: Cluster analysis of word similarity by age groups (complete statements)

Table 2: Reference to concept of competition

Concept	Age 8 boys	Age 8 girls	Age 11 boys	Age 11 girls	Age 16-18 boys	Age 16-18 girls	Total
Competition	20,0	45,0	15,0	0	10.0	10.0	100% (20)

4.3 In depth analysis

The only games that the youngest participants (8 year olds) played in school were educational games. All of them reported enjoying those and competition was frequently mentioned as a key motivating factor. All of them claimed to play digital games in their own free time. The most frequently mentioned entertainment games, like Hay Day, Clash of Clans and Minecraft, were played equally by both girls and boys. There were, however, some differences in gaming preferences. More girls mentioned games related to music, looks and pet care whereas more boys referred to racing games and shooting games. Only boys mentioned games with age limits above their own age. In fact, playing games with high age limits, seemed to be status related. When several of them proudly reported playing shooting games, the fact that they had high age limits was something they'd make sure to mention. They also boasted about hiding the forbidden playing from their parents, for example quickly turning to another activity when a parent approached their computer. 8 year old Kasper, who reported playing the Japanese horror game Ao Oni said "It's scarier than you'd think. It is one of those 14-year-old-age-limit games". When asked if he was allowed to play it, he responded "I am allowed to play it secretly". Two boys reported playing GTA, (Grand Theft Auto), a game with an 18 year old age limit. When one of them, Robert, was asked if he was allowed to play GTA, he responded:

> *Robert: I didn't know that it was GTA. I don't look at it any longer, I didn't know it was GTA, so I looked at it by accident.*
>
> *Interviewer: Would you have played a game like that if you had been allowed to, even if there was an 18 year old age limit?*
>
> *Robert: Maybe… it is a long time until I'll turn 18 and can play it. I really want to play it.*

Like their younger peers, the 11 year olds appreciate DGBL. They only games they were exposed to at school were educational games and many even reported playing games from a popular educational gaming site in their free time. In the 6th grade interviews only two participants mentioned games with age limits above their age, in neither case did they mention the age limits, nor did they seem to find the age limits relevant. In one case an 11 year old boy, Filip, revealed playing Tekken 6, a game with a 16 year old age limit. In the other case a girl named Sara, played GTA (18), having gotten it from her older brother when he got tired of it.

Also here, Minecraft seemed to be the most popular game, 8 of the 11 year olds mentioned playing Minecraft, 3 (out of 7) boys and 5 (out of 8) girls. Fifa and Clash of Clans were also popular, although both seemed to appeal more to the boys.

DGBL was also generally appreciated at the upper secondary school level, although this age group (16 and 18 year olds) gave more reflective answers than the grammar school pupils and some voices were somewhat critical. They had experienced both educational games and commercial games in school, although the 18 year olds currently only had commercial games in their DGBL. Gender differences appeared in two ways at this level; in the way girls and boys talked about gaming and which games they played – and in the way they directly addressed gender differences.

Only 1 of the 19 upper secondary school boys voiced direct criticism of DGBL, as well as 1 out of the 13 upper secondary school girls. However 3 other girls also hinted at some reservations towards it, at the same time as they acknowledged this teaching approach for its positive sides, such as being a welcome variation to regular teaching.

When asked what they play in their pastime, fewer girls than boys admitted regular gaming. In total 8 of the upper secondary school girls reported not playing much or at all, when first asked. After some inquiries 7 of them admitted playing, to varying degrees – only one claimed not to play at all for the time being, although she had played some Tetris on her phone before. Only 3 of the upper secondary boys reported not playing much for the time being. While Skyrim was the most frequently mentioned game within this age group, only 2 girls reported playing Skyrim, as opposed to 11 boys (out of 19 in total). In some cases it turned out that they did not count mobile games as "real games", in other cases the playing was connected to social activities with boys. Natasha (16), who initially claimed not to play, said: "I don't really play much… or I do like gaming and all… sometimes I play with my brother. We usually play Fifa, Assassins Creed and Call of Duty."

As for specific gender differences, the 18 year old upper secondary school students were the only age group that brought up gender differences on their own initiative, several times. The fact that this was the only group where the males greatly outnumbered the females, by about 5 to 1 in the class, may have had something to do with their gender awareness, as it seemed to be a familiar topic to them. This was also the only group that currently had only commercial games in their DBGL. Jeanette, the only girl who outspokenly criticized DGBL, claimed that none of the girls actually liked it.

> *Jeanette[2]: Perhaps because the boys have always found it fun and cool... with zombies and stuff... but I don't really know. Personally I have never found zombies... nor games in general, particularly fun. But of maybe that's just me.*
>
> *Trond: I agree. It is typically more common for boys to play much more and be much more fond of zombies and violent films and stuff... so this is an understandable difference.*

In an 18 year old male-only focus group, games were said to be "male dominated". The participants commented on the (few) girls in the class expressing skepticism towards games, yet seeming to participate actively in the discussion parts of the DGBL sessions. "They just don't want to admit it… that they like the games…" Arne, age 18, said that he and his classmates, Sindre and Dag, felt it might have to do with which types of games were employed. When asked to further elaborate what kinds of games might appeal more to girls, Sindre responded with something that made the other young men in the group laugh:

> *Uhm… well… I just think that you have this "typical" chasm between boys and girls, right? Boys likes shooting and violence and killing and zombies and stuff… and then you have the girls… who are a little more… like, flowers…*

He went on explaining that girls were more likely to play games like Sims, whereas boys were more likely to play games like The Walking Dead. When asked if they thought there would be a game that would be equally fit for both genders, all three agreed on the game Civilization.

5. Discussion and conclusion

Our statistics show that as children, girls are less likely to attend free courses on game coding. We also see that young females are less likely to sign up for IT-related studies than young men are. Our statistics for the last 25 years show that at one point women represented up to 45% of total applicants but are now down 10% or less.

Although some games are generally appreciated by both genders, we see some gender divisions throughout the age groups. We also see that 8 year old girls mention competition with regard to games, over twice as often as boys. At the age of 11, however, no girl mentions competition, while boys mention competition 15 times. In the oldest group competition seems to be discussed equally by boys and girls.

Given that young boys play games that are meant for audiences around and above the age of 18, whereas girls only play age appropriate games, it seems possible that the boys learn concepts and vocabulary fitted for an older audience. Perhaps this also influences their appreciation for competition. To speculate further, it would be interesting to find out if there might be a further correspondence to the boys' increased digital confidence, as opposed to the girls'.

In the oldest age group, 16 – 18 year olds, we can see that some gender roles and norms are intertwined with the individual's perspectives. Although the vocabulary does not seem to differ much (according to content analysis), young women this age are less likely to admit playing a lot. They play more "casual games" (e.g. Candy Crush), whereas the boys play more complicated and time consuming games (e.g. Skyrim). They see digital games as a gendered genre and they express different preferences, where the girls simply do not like "masculine" entertainment like zombies and the boys assuming that digital games must be about "flowers" for the girls to feel motivated. Young women also express slightly more critical views towards DGBL than their male classmates do. This skepticism could be a reflection of a wider skepticism towards IT in general, which again would explain the absence of female applicants to game design studies at our University-College.

What is the difference in the way young girls and boys perceive DGBL? Our data shows us that both young girls and boys recognize the worth of DGBL. They play somewhat different games in their free time. As they grow older, we see more signs of skepticism towards DGBL amongst young women, and the 16 - 18 year old participants seem to have an internalized perception of gender differences. It strikes us that this appears to be a backlash in the social equality. Are we being transferred right back to square one?

While a small study like this does not allow for any concrete conclusions, a correlation is likely between the different perspectives of the genders and the fact that fewer young girls and women seek courses and education in digital game design and IT. Further research is needed on the underlying factors that shape the gender specific perspectives of boys and girls with regard to games and IT. Research on initiatives that aim to counteract this difference and empower girls and young women to seek IT-careers would be of interest.

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E-Learning Sudan, Formal Learning for Out-of-School Children

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Abstract: E-Learning Sudan (ELS) is a custom-built computer game that provides alternative learning opportunities to Sudanese children who are excluded from education. Unique in ELS is that children can learn mathematics, in their own remote village, without a teacher. This research study assessed the effectiveness of ELS through a pretest–posttest control group quasi-experimental design. Participants consisted of 67 children in three remote villages, aged between 7-11, that had never been to school before. The control group consisted of 19 children in a fourth remote village. The experimental group used the game for a period of six weeks, five days a week, 45 minutes a day. The results of the analysis on the pretest–posttest data revealed that ELS increased mathematics knowledge acquisition in numeracy and adding significantly and maintained student motivation to learn. The findings suggest that the implementation of ELS can greatly benefit learning for out-of-school children like in Sudan.

Keywords: game-based learning, autonomous learning, primary education, mathematics, developing countries

1. Introduction

Education for children in the developing world is in crisis, and children growing up in war are already at the sharp end of global development challenges.The push to achieve the goal of educating every child at least to primary level (enshrined in the Millennium Development Goals) puts pressure on educational systems which already struggled to cope with demand. Although the push towards universal access has substantially increased education enrollment, in 2011 57 million primaryschool age children were out of school. Globally, 123 million youth (aged 15-24) lack basic reading and writing skills: 61 percent of them are young women (un.org/millenniumgoals/education.shtml). Reaching those without access to school is a pressing issue, particularly girls and children in the rural areas in Africa and South Asia (Burnett 1996; Kallaway 2001; Cremin2012). Equity still remains a major issue, not only involving girls, but also the poor, including linguistic and ethnic minorities, and other disadvantaged groups (Burnett 1996; Kallaway 2001; Novelli 2008).

Besides limited access, educational quality is low at all levels in most low and middle income countries (Burnett 1996; Boissiere 2004; Dembélé 2007; Vavrus 2009; Mtika 2010; Sriprakash 2010; UNESCO 2012; Lavy2012). There are not enough qualified teachers, class sizes are large and teaching methods are teacher centered. This leads to high drop-out levels, up to 50% (Sriprakash 2010).

As with other Sub-Saharan countries, Sudan struggles with the same issues (The World Bank 2012). There are approximately two million children in Sudan not in school. At present, it is not realistic to believe that this will be solved through traditional means. Due to the cultural, geographic and socio-economic background of children, more flexible, empowering and affordable approaches outside formal schools are required. Online and distance learning with ICT are seen as possible solutions. The focus of this approach should be on rural areas, communities affected by conflict – includingInternally Displaced Persons (IDPs)- and specifically include girls and minority groups.

Although the children will need to learn how to read and write as well, for pragmatic reasons we have chosen to start with mathematics.The curriculum in the game is based on the official curriculum for out-of-school children in Sudan for Grades 1, 2, and 3 and leads to an official certification (Stubbé in press).The game supports autonomous learning and consists of a game world and various mini-games to practice each mathematics concept. It provides instruction, and has a management system that tracks progress and ensures that children do the mini-games that match their knowledge and skills. In addition, language and graphics are designed to be culturally appropriate.

By playing the game, children are actively involved and can learn at their own pace. Because this way of learning is completely different from the formal school system in Sudan, and because the targetedchildren in remote, rural communities have never been to school, a proof of concept was needed before the three-year curriculum could be developed into a game. The most important question that needed to be answered was if children can learn mathematics by playing the game. Following the 'fastest route to failure', a small part of the game (six weeks of the curriculum) was developed and tested in three communities.

2. Acquisition of mathematical skills

Research shows that children develop mathematical skills at different levels before beginning formal schooling (USAID, 2009).Children across cultures seem to bring similar types of skills to school, but do so at different levels (Guberman 1996). In general, children from low-income backgrounds begin school with a more limited skill set than those from middle-income backgrounds. This is related to the environment in which children grow up that enables them to understand the world, master language and get insight in the basic knowledge needed for mathematics (Greenman 2011). This means that these children will need additional support to ensure success (Chard 2008). Where in developed countries this support is usually given as extra support to individual children, in developing countries early interventions should be aimed at all children.

Furthermore, the rate of acquisition of mathematical skills can be influenced by the opportunities children have in their communities (Guberman 1996). Household tasks and chores can get in the way of developing these skills, but they can also enhance the acquisition of these skills because they provide meaningful learning opportunities. Once children begin formal education, they use this informal knowledge when completing new tasks (Baroody in Copely 1999; Ginsberg 1981).

Between the ages of 3 and 9, the construction of number knowledge develops in more or less the same ways (USAID 2009). With formal schooling, children start developing a new understanding of mathematics. With continued practice, they become more familiar with numbers and their values, and their confidence grows; children process information faster in solving mathematical problems. Becoming efficient at mathematics requires the automatization of the subsequent stage, rather than repeating the earlier stages. Children need to free up cognitive resources to be able to solve more complex problems (Pellegrino 1987). With continued practice, children become more confident in their computational and problem solving skills (Fusonin Kilpatrick 2003). This puts asignificant emphasis on good early mathematics experiences for children.

Across countries, curricular and conceptual goals show similar subjects (USAID 2009):

- developing an understanding of whole numbers, including concepts of correspondence, counting, cardinality, and comparison;
- representing, comparing, and ordering whole numbers, and joining and separating sets;
- developing understandings of addition and subtraction, and strategies for basic addition and subtraction facts, including whole-number relationships (e.g. tens and ones); and
- developing understanding of base-ten numeration system and place-value concepts, including fluency with multi-digit addition and subtraction.

This means that a mathematics game aimed at the first three grades of primary school, should comprise at least these subjects.

Because this project focuses on vulnerable children with little support from parents or teachers, we assume them to have little informal knowledge. Besides, the opportunities to learn from everyday life situations in the communities are scarce. Because of this the approach for struggling learners is followed. One of the major issues in supporting struggling learners is to make sure that there is a strong basis to build on. This corresponds with the concept of mastery learning (Bloom 1985), where 'the students are helped to master each learning unit before proceeding to a more advanced learning task'. Furthermore, struggling learners need explicit instruction (Timmermans 2005; Milo 2003). Research (Bodovski 2007) shows that struggling learners show less engagement during instruction. If this engagement is increased, performance increases as well. A focus on 'time on task' (Carroll, 1963) could help to improve learning results; for all children can learn mathematics, but some need more time than others. To support struggling learners, instruction and exercises on the mathematical skills that are often acquired informally are included in the game. In addition, direct instruction is given; instruction that explains how to 'do it'. The language of instruction is basic, formal Arabic, which most children understand well. The instruction in the videos is provided by slightly older children (14-15 years), which is assumed to increase motivation to watch the instruction videos. Furthermore, theseolder children can also be seen as role models, increasing motivation to learn and self-efficacy.

3. Method

Following the 'fastest route to failure', a small part of the game - six weeks of the curriculum - was developed and tested in three communities.

This research study used a pretest–posttest control group quasi-experimental design. Participants were67 children in three remote communities in Sudan (Mona, OmTifag, and Wad Almoshmer), aged between 6-11. The control group consisted of 19 children in a fourth remote (OmOkaz). None of the children had been to school before. The experimental group used the game for a period of six weeks, five days a week, 45 minutes a day, while supervised by a facilitator. The control group did not receive any education in the same period. In addition to the test results, the following data were collected: attendance, motivation (observed by facilitator) and the logged data in the mathematics game.

3.1 Participation

In the communities, all children between the ages 6 and 12 were invited to participate in the experiment. Parents were informed about the goal and the method. The community was involved in setting up the 'learning centers' (sheds where the children gathered to learn). Children were assigned to morning or afternoon learning sessions, according to their parents' wishes. In this way learning could fit in with their chores and household tasks.

3.2 Learning Sessions and Hardware

Because there were two learning sessions a day, the hardware could be shared.Each laptop was used by two different children. Consequently, hardware stayed in the learning center, locked away until the next session.

3.3 Facilitator

Each community had one facilitator. A facilitator encourages the children to work with the mathematics game and helps them with technical problems. The facilitator was not supposed to teach or explain the principles of mathematics. Facilitators were trained to take this role and to solve technical problems. During the week, facilitators lived in the communities, in the weekends they could go to their own homes.

3.4 Observer

Observers attended the learning sessions twice a week, to observe if the facilitator followed instructions. They also took the mathematics test with the children.

3.5 Staggered approach

A staggered approach was used: the pilot started in Mona, after two weeks OmTifag started. Last of all, again two weeks later, Wad Almoshmer started. In this way the start of the pilot in each community could be supported by all observers and supervisors. Moreover, the technical issues that arose in the first community could be solved before the other communities started. The control group, Om Okaz, was tested later, but also with a six-week interval between pretest and posttest.

3.6 Oral test

An oral test was used because all children were assumed to be illiterate. This test was designed on the basis of the Early Grade Mathematics Assessment (EGMA, USAID 2009), and consisted of 30 items (maximum score was 60 points), covering the very basics of mathematics: oral counting, number identification, one-to-one correspondence, quantity discrimination, word problems, addition and writing down numbers. The numbers in this test ranged from 1 to 10. The same test was used as a pretest and posttest.

3.7 Test protocol

As the children lived in remote communities, it was assumed they had not been tested before in any formal way. Reports on the testing of children in developing countries mention that children are shy to answer any questions at all (Kanu2013). To make sure children were as comfortable as possible taking the test, observers travelled to the communities a day early, stayed the night and built relationships. The test was taken on the second day. A test protocol was designed and observers were trained to use it. During testing, a supervisor was present to ensure that the testing was performed according to protocol.

3.8 Ethics

The ethics committee of the Ahfad University for Women in Khartoum has approved this pilot study. In addition, agreements have been signed by White Nile State and the participating communities. All facilitators signed a child safety protocol. Om Okaz, the control community in this pilot, will participate in a next pilot. Parents have signed consent forms for their children to take part in the experiment and to be photographed. All data are related to a child-specific number. This is done for privacy reasons, as well as for pragmatic reasons (Arabic names can be spelt in different ways in English).

4. Results

The experiment was conducted in the period of December 2012 to February 2013.

4.1 Participants

A total of 86 children participated in the pilot. 67 of them were in the experimental group, 19 were in the control group. Three communities were included in the experimental group. All the children in the communities that had never been to school before were invited to participate, boys as well as girls, irrelevant of age. There were more boys than girls, in the experimental condition (56%-44%) as well as in the control group (60%-40%) (see Figure 1). This reflected the situation in the communities; girls were not excluded from the pilot. There was no significant difference in participation of girls and boys between the experimental communities and the control group.

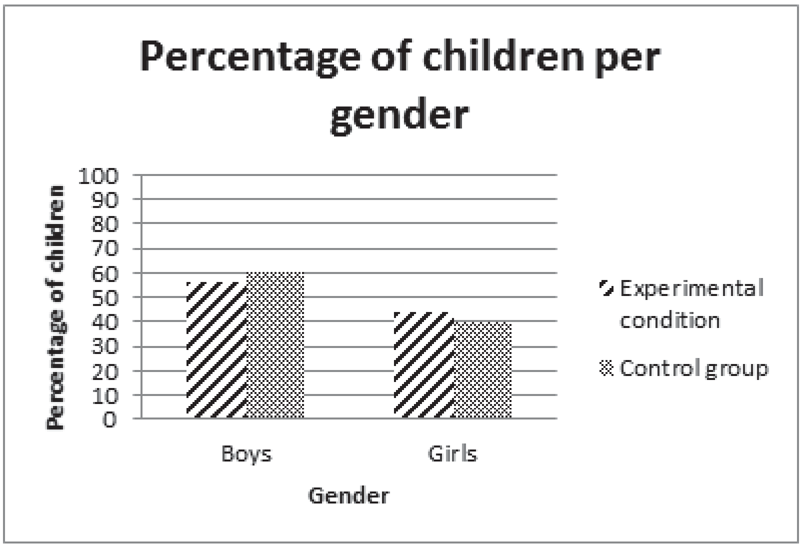

Figure 1: Percentage of children per gender

The children's ages varied between 6 and 11, with most children at the age of 8 and 9 (see Figure 2). There was no significant difference between the average age in the experimental condition and the control group (8.3). In the experimental condition the percentage of 7 and 8-year olds was higher, though. The average age in this group was influenced by three 10-year olds and an 11-year old.

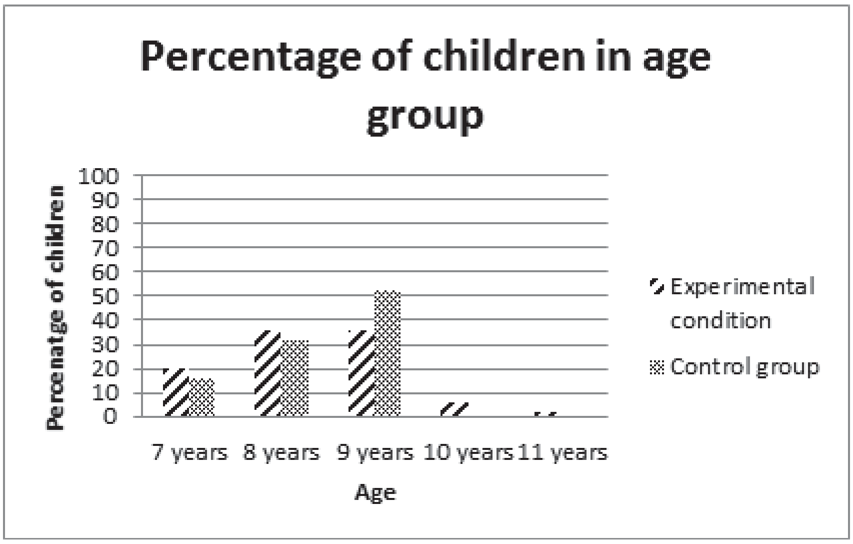

Figure 2: Percentage of children in age group

In the experimental group, a total of 67 children participated in the pretest. 54 of them did the post-test as well (see table 1 below). There were various reasons for this drop out. In Om Tifag two boys achieved high scores on the pretest. They were excluded from the experimentbecause they had been to school before. In Wad Almoshmer, a six-year-old boy from another community became very homesick after a few days and was returned to his own community. He did not participate in the pilot any further. In Mona, one girl refused to answer on the posttest. Her data were, therefore, excluded. Apart from these four, 10 more children did not take the posttest. Three children were not present during testing, seven had dropped out of the experiment for reasons unknown.

Table 1: Number of participants, per community and per activity

	Mona	Om Tifag	Wad Almoshmer	Om-okaz	Total
Pre-test	20	24	23	19	67 + 19
Observations	20	22	18	-	
Logged data	20	22	18	-	
Post-test	19	20	15	19	54 + 19

4.2 Facilitators

During the experiment one facilitator was replaced because he had not followed instructions; he lived in a community nearby, and walked home every day instead of living in the community during the week.

4.3 Technical problems

There was one technical problem in the first week in the first community. The game depends heavily on audio and video, because the children cannot read and write. In the first few days of the pilot, it became clear that the children would need earphones to be able to hear the instruction from their own laptop. This was arranged within a week. This was solved before the pilot started in the other two communities. Furthermore, there was a software problem: the first four levels in the game were adequately developed. For the fifth level, the instruction video had not been included, which made it difficult for the children to understand what they needed to do in that level.

4.4 Data collection

Although unique numbers were used to ensure anonymity, some observers only wrote down the names of the children. Because of the many ways in which Arabic names can be written down in English, it was hard to match the collected data for nine children. In collaboration with the observers, the names were matchedwith the unique numbers.

4.5 Test results

The experimental group had an average of 33% correct answers on the pretest (N=67, M=20.3, SD= 11.5). The control group had an average of 28% correct answers on the pretest (N=19, M=16.5, SD= 5.6). An independent T-test showed no significant differences on the scores of the pretest between the experimental group and the control group (t=-1.4283, fd=79, p=0,16). The average score of the experimental condition on the post-test was 55% correct (N=54, M=33.1, SD=15.5), the control group showed a slight increase to 29% correct answers (N=19, M=17.2, SD=5.3). An independent T-test showed a significant difference between the posttest scores of the experimental condition and the control group (t=-4.5059, df=79, p=0.00).Furthermore, an independent T-test showed significant differences on the delta scores (posttest-score minus pretest-score) between the experimental group and the control group (t=9.1, df=71, p=0.00) (see Figure 3). This means the experimental group has learned significantly more than the control group.

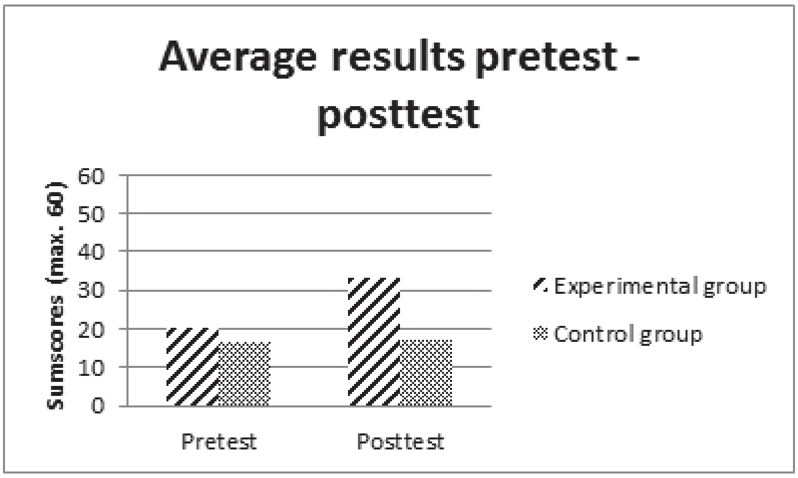

Figure 3: Results pretest-posttest

All the children that used the game have improved significantly. The children that did not use the game (control group) did not improve significantly. Although all the children in the experimental condition have improved, the children with a lower score on the pre-test, increased their scores more than the children with a higher score on the pre-test. The increase varied between 9 and 42 points. There were no significant differences between boys and girls or between the different age groups.

This overall score on the test is an indication of what the children have learned. The specific measures used in the test provide more insight in children's knowledge and skills. Table 2 (below) shows the percentage correct on the various measures. For each measure there were a number of questions.

Table 2: Percentage correct per measure, pre-test and post-test

	Experimental condition		Control group	
	Pre-test	Post-test	Pre-test	Post-test
Oral counting	29.8%	70.5%	33.3%	38.3%
One-to-onecorrespondence	89.6%	100%	95.8%	97.5%
Number identification	28.3%	87.5%	23.3%	29.2%
Quantity discrimination	47.8%	95.8%	30.0%	35.0%
Word problems (addition)	29.5%	53.3%	17.5%	21.3%
Addition	23.1%	58.8%	17.3%	17.3%
Writing	49.3%	78.5%	48.8%	51.3%

In the experimental as well as in the control group the percentage correct on 'one-to-one correspondence' is notably high in the pretest. The percentages correct on 'quantity discrimination' and 'writing down a number' are higher than the percentage correct on the other measures for both the experimental as well asthe control group. Children in the experimental group as well as in the control group improve their scores on all measures, except for the control group on 'adding'. The increase of scores, however, is much higher in the experimental group than in the control group. With 'one-to-one correspondence' this is only 10.4%, due to a ceiling effect: the scores on the pre-test were very high, improvement to 100% was only 10.4%. The children in the control condition improved their percentage correct as well, but only with a few percent per measure.

4.6 Logged data

The logged data show that with a few exceptions all the children used the game five days a week during the pilot period. Approximately 30% of the children completed all the materials in the game. The other 70% of the children finished between 50-70% of the materials. The children that had finished before the pilot ended were told to start again from the beginning.

4.7 Observations

Observation forms were filled out daily. Facilitators scored attendance and motivation for each student. The observation forms show that most children were present during sessions and that they were motivated to learn most of the time (see figure 4). There were differences in motivation in the communities at the start of the experiment, but average motivation increased during the six weeks (from 2.7 to 3.2 on a 4-point scale). There were some differences between the communities: in Mona there was a decrease in motivation during the first week. This could be explained by the fact that the children did not have headphones, and could not hear the instruction. After this was solved, motivation increased again. In Wad Almoshmer, motivation in the first week was at a maximum. Later, motivation decreased towards a more average level.

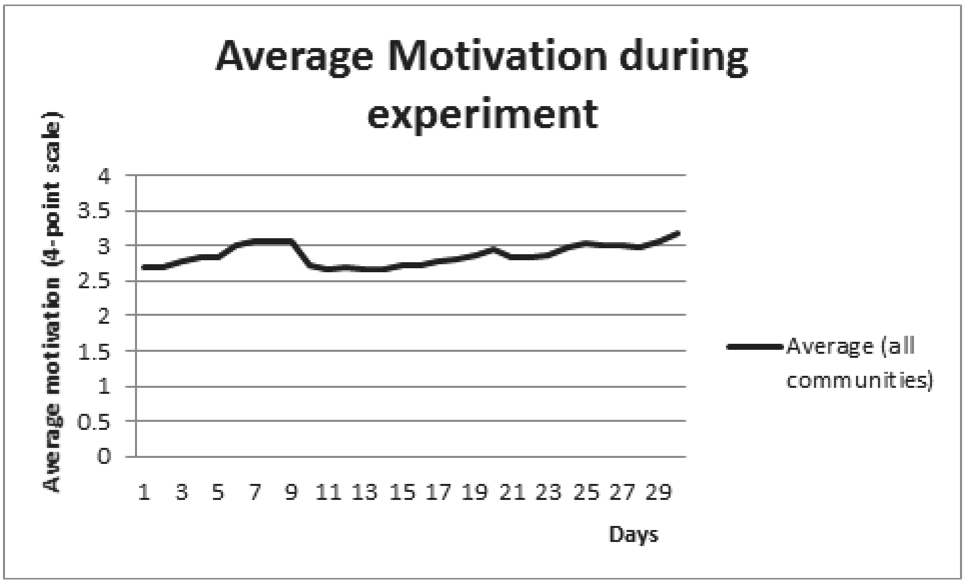

Figure 4: Motivation during experiment

The children loved the instruction videos very much, and some watched them twenty times. When asked about this, they would say that the older children in the videos were their big brother or sisters (role model); 'If she can do it, I can do it as well!' They also loved the many games and the colors in the game.

Initially, the children were rather shy. As the experiment continued and researchers came to the communities more often, the children became more outgoing. They were very proud of what they had learned and wanted to show their improvements. Also adults were more engaged in a range of activities and were interested to learn themselves. One of the children participating in the experiment was a boy that was physically handicapped. Because of his slurred speech, people thought he was retarded as well. He performed very well with an average improvement of 15 points. He is now more accepted by the other children, and even his speech has improved.

After the six-week experiment the children were taught by teachers in their own community for the rest of the school year. At the end of this period they were tested by a nearby school. Ten children were admitted to Grade 4, five children were admitted to Grade 2 (which would be normal progression) and the rest was admitted to Grade 3. The progress of the ten children admitted to Grade 4 was followed carefully. At the end of Grade 4 they were the top 10 of their year. This shows that the children not only learned their mathematics, but also formed a strong basis for further development.

5. Discussion and conclusion

In this experiment we aimed to test if children in rural areas in Sudan could learn mathematics autonomously, by playing a mathematics game on a computer. All the children in the experimental condition have improved their scores on a mathematics test significantly in the six weeks that they used the mathematics game.During the same period the control group, who did not play the mathematics game, did not improve their scores. This proves that the increase in mathematics scores in the experimental was not caused by maturation or a test effects - as a result of taking the same test within six weeks - but by playing the game. This shows that children can learn from the mathematics game, with only a facilitator to supervise them.There was no significant difference between boys and girls; the game is as effective for girls as it is for boys.

The increase in scores varied between 9 and 42 point. In general, children with a lower score on the pre-test improved more than children with a higher score on the pre-test. This is probably due to a ceiling effect: the game and the test focused on the very beginning of mathematics. Children that already had some knowledge of mathematics, achieved a higher score on the pretest and thus had less room for improvement. In addition, the game taught the basics of numeracy and addition. Children that knew how to do this could not learn very much from the game. They were the ones that went through the initial mini-games quickly. Other took longer to understand the basics of numeracy. Since the game offers children the possibility to learn at their own pace, they would always be playing mini-games that suited their knowledge and mathematical skills.

The percentage correct of all measures increased in the experimental condition.Four of the measures increased most: 'oral counting', 'one-to-one correspondence', 'number identification' and 'quantity discrimination'. The version of the game used in this experiment specifically teaches these subjects.This shows that the game has a strong effect on the increase of knowledge on the subjects taught. Writing was not part of the game, and there was no instruction video for 'adding'.The percentage correct on these measures did increase significantly, but not as much as on the other measures.

When children learn autonomously, without a teacher to give instruction and feedback, and motivate them, there is always the issue of motivation. Will they stay motivated to keep on learning for a longer period of time? During the six-week experiment average motivation stayed high, and increased slightly. Although six weeks (30 days) isquite long for a pilot, it may prove difficult to keep children motivated for an even longer period of time. This should be researched in a longer pilot.

The most important goal of this study was to prove that children can learn from playing the mathematics game. As this method of learning is completely different from what is generally used in Sudan, a 'proof of concept' was needed before the rest of the game was developed. This experiment has proved just that, and so much more. Children, and parents, in remote rural communities are very motivated to learn when they are given the possibility. The assessment by nearby schools showed that all children in the experimental group learned as much or more than children in the same time in formal education. The children that actually went to Grade 4 in a school – after only one year of education - did very well. Children, and parents, became more active and outgoing during the six-week experiment. Because all children in the communities could participate, a boy that was assumed to be retarded was involved in the experiment. He was able to play the game and learn. This has changed the way others see him, and improved his quality of life.

At the same time, this was only a small experiment in three communities in one state in Sudan. A larger experiment, with more children, in more communities and more states is needed to confirm that these positive results can be repeated with a larger group of children from various backgrounds, over a longer period of time, teaching more, and more difficult mathematical concepts.

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Building an Emotional IPA Through Empirical Design With High-School Students

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Abstract: As suggested by Woolf, one of the Artificial Intelligence (AI) grand challenges in education is "mentors for every learner". Mentors can be implemented as Intelligent Pedagogical Agents (IPAs) in order to motivate students: "The first way such systems [IPAs] must evolve is to directly address 21st century skills such as creativity, critical thinking, communication, collaboration, information literacy, and self-direction." AI provides the tools to build computational models of student's skills and scaffold learning. Further, AI methods can act as catalyst in learning environments to provide knowledge about the domain, students, and teaching strategies through integration of cognitive and emotional modelling, knowledge representation, reasoning, natural language question answering, and machine learning methods. In this paper, we describe the design and development of an Intelligent Pedagogical Agent that will guide the students through the use of a Serious Game implemented to teach STEM subjects. The use of IPAs is proposed as a support during the game evolution because they act as learning facilitators and guide the learners in the virtual environment by explaining topics, answering questions, giving feedbacks, helping the learners to collaborate with others, providing personalized learning support. The IPA that we propose in this paper behaves along two paths: *emotional*, as the interaction depends on the feelings of the student, and *pedagogical*, i.e., by giving tips and advices related to the topics and to the tasks assigned. The emotional part of the IPA has been built conducting a study on emotions with high school students. On top of the results coming from the study, it has been built an Android application that uses the IPA as a standalone application to prove the efficacy of the IPA itself.

Keywords: intelligent pedagogical agent, emotional learning, serious game, empirical design

1. Introduction

The development of an Intelligent Pedagogical Agent (IPA) is one of the core part of the development of a Serious Game to teach STEM subject in high school (cf. our previous work: Annalisa Terracina, Massimo Mecella. Combining Virtual Learning Environments and Intelligent Pedagogical Agents for a new approach to classroom lessons. ECGBL 2014 conference proceedings). The agent should behave along two paths: *pedagogical* and *emotional*. Emotions are important for students in two major ways. First, emotions have an impact on learning. They influence our ability to process information and to accurately understand what we encounter. For these reasons, it is important to create a positive, emotionally safe environment to provide the optimal learning to students. Second, learning how to manage feelings and relationships constitutes a kind of "emotional intelligence" that enables people to be successful. Emotional intelligence expands on Howard Gardner's theory of multiple intelligences, in particular, the intrapersonal and interpersonal intelligences he defines, which deal with understanding oneself and others.

2. State of the art

One of the most influential papers in the area of emotional learning is still a study from Lester, Converse, Khaler et al (1997) that demonstrated a Persona Effect, in which learning was facilitated by an animated pedagogical agent that had a life-like persona and expressed affect. The rationale for this research has been the media equation hypothesis of Reeves (1996). He suggested that learners respond to pedagogical agents as if they were social actors, then the agents' effectiveness should depend upon whether or not they behave like social actors.

The paper from Wang et al. (2008) starts from the premises made by Reeves and Nass but goes beyond the Persona Effect stating that social intelligence in pedagogical agents may be important not just to gain user acceptance, but also to increase the effectiveness of the agent as a pedagogical intervention. To test this hypothesis, they developed a model of motivational tutorial tactics based upon the politeness theory by Lester, Johnson and Rickel. A preliminary series of Wizard-of-Oz studies has been conducted by the authors, in which learners either received polite tutorial feedback that promoted learner face and mitigated face threat, or received direct feedback that disregarded learner face. The paper demonstrate that the polite version of the agent led to improvements in learning outcomes, and the effect was amplified in learners who expressed a preference for indirect feedback. The authors termed the effect demonstrated in the paper the *Politeness Effect*. Their results suggest that pedagogical agent research should perhaps place less emphasis on the Persona Effect in animated pedagogical agents, and focus more on the Politeness Effect and related means by which pedagogical agents can exhibit social intelligence in their interactions with learners.

The paper from Zeng (2009) examines available approaches for solving the problem of machine understanding of human affective behaviour and discuss important issues like the collection and availability of training and test data. They outline also some of the scientific and engineering challenges to advancing human affect sensing technology. The paper start describing which are the most common approaches to the study of emotions and with the difficulties that arose trying to automatically recognize emotions in HCI. In fact, while automatic detection of the six basic emotions in posed controlled audio or visual displays can be done with reasonably high accuracy, detecting these expressions or any expression of human affective behaviour in less constrained settings is still a very challenging problem due to the fact that deliberate behaviour differs in visual appearance, audio profile, and timing from spontaneously occurring behaviour. Due to this criticism received from both cognitive and computer scientists, the focus of the research in the field started to shift to the automatic analysis of spontaneously displayed affective behaviour. It has also been shown by several experimental studies that integrating the information from audio and video leads to an improved performance of affective behaviour recognition, thus the importance of the integration of information from multiple modalities (vocal and visual expression in this paper) to yield a coherent representation and inference of emotions.

The work done by Shen et al. (2009) describes the development of an affective e-Learning model, and demonstrates the machine's ability to recognize learner emotions from physiological signals. Pervasive e-Learning Platform was one type of e-Learning platforms that provided "always on" education. The goal of this study was to understand how learners' emotions evolve during learning process, so as to develop learning systems that recognize and respond appropriately to their emotional change. The proposed affective model, based on Bayesian Network study, indicated that the user's emotional states were related to learner profiles (e.g., learning preferences, cognitive skills, knowledge structure), goals of learning, and learner interaction with the learning system. The user's emotional states would in turn influence the measurements of the available sensors. For instance, the user's emotional state was assessed using existing information on learner profile and learning context, even in absence of reliable sensors. Using physiological signals to predict emotions, this study explored the emotion evolution during learning, and proposed an affective e-Learning model. When learner emotions detected were feed back to the affective e-Learning model in real time, the content recommendation system delivered proper learning content or entertainment content according to learner's current emotional states and other learning contexts. The experiments indicated the superiority of an emotion-aware system over a non-emotion-aware system with an increase of 91%, which suggested that using emotional data could greatly improve the performance of e-Learning systems, particularly in the categories involving user-centered learning.

In the paper from Conati (2002) it is presented an approach to a possible modelling of user affect designed to assess a variety of emotional states during interactions: knowing the details of a user's emotional reaction can enhance a system capability to interact with the user effectively. This paper start from some theoretical base very similar to the one proposed by Shen et al. but instead of reducing the uncertainty in emotion recognition by constraint the task and the granularity of the model, the proposed approach explicitly encodes and processes this uncertainty by relying on probabilistic reasoning. In particular, the author use Dynamic Decision Networks (Dean and Kanazawa 1989; Russell and Norvig 1995) to represent in a unifying framework the probabilistic dependencies between possible causes and emotional states (including the temporal evolution of these states), and between emotional states and the user bodily expressions they can affect, like the paper from Shen. Conati discusses her model in the context of the interaction with *pedagogical agents* designed to improve the effectiveness of computer-based educational games. She also introduces Dynamic Decision Networks and illustrate how they can be used to enable pedagogical agents for educational games to generate interactions tailored to both the user's learning and emotional state. As stated by the author, the usage of multiple sensors is used to validate the outcomes of the theoretical model and so it does not differ so much from the approach followed in the paper by Shen. The difference is that while all the effort are put in the correct reaction of the pedagogical agent in a game environment in Conati work, in the paper from Shen, the effort was put in the real-time feedback to human teachers in an ongoing lesson.

In the paper from Johnston, Zakharov and Mitrovic (2008) it is presented a pedagogical agent capable of active affective support, guided by the logic which integrates the learner's cognitive and affective states. According to the authors there are two major theoretical approaches to the study of emotion: dimensional and categorical. Zakarhov et al have chosen the dimensional approach in order to avoid complicacy due to the continuous of the possible emotions. They developed an algorithm for feature tracking which utilizes a combination of common image processing techniques, such as thresholding, integral projections, contour-tracing and Haar object classification. Throughout the algorithm, the focus of attention is shifted among a number of regions of interest, determined on the basis of the anthropomorphic constraints describing human face geometry.

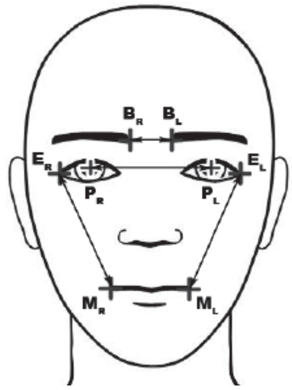


Figure 1: Anthropomorphic constraints describing human face geometry

The algorithm relies on a few session-dependent threshold values for processing eye, brow and mouth regions. The feature detection algorithm includes five steps: (1) face region extraction; (2) iris detection; (3) outer eye corners detection; (4) mouth corners detection and (5) inner brow corners detection. In the experiment described in the paper, the authors created two female and two male Haptek characters. The agents were designed to appear as young people approximately 20 to 30 years of age. In order to evaluate the affective agent, they performed a study in an introductory database course: the experimental group had access to the affectaware version of the agent, while the control group had the affect-unaware version of the agent. The experiment results indicate a range of preferences associated with pedagogical agents and affective communication. Affective interaction is individually driven, and it is reasonable to suggest that in task-oriented environments affective communication carries less importance for certain learners. Paper conclusions are that although the interplay of affective and cognitive processes always underpins learning outcomes, affective interaction sometimes may need to remain in the background; whatever the case, an ITS should let the user decide on the level of affective feedback thus leaving the user in control.

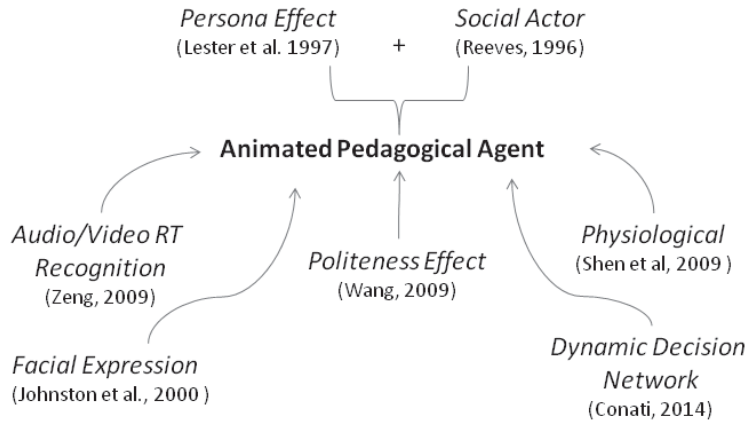


Figure 2: State of the art summary

Figure 2 reports a summary of the state of the art. Two major papers from the end of the nineties introduced the Persona Effect and the concept of the agent like a Social Actor leading to the idea and development of Animated Pedagogical Agent. Most of the recent works try to put together sensor technology (audio/video systems, brainwaves signal, etc) with emotional model (dimensional, categorical) in order to properly recognize and manage user's emotions. Some paper, like the one from Wang et al, put emphasis on the politeness effect, that is to say the empathic and polite behaviour of the agent as a point of strength for the success of the agent usage. Other paper, like the one from Conati, put more research effort on Artificial Intelligence technique to better model agents answers and suggest a combination of AI technique and sensor analysis.

In our research project we have constructed an IPA that makes use of some AI technique to discover student emotions in real time and not sensors. In particular we have decided to use what it is known as sentiment analysis (Pang and Lee, 2008) performed on student sentences during the interaction with the IPA (students can chat with their virtual tutor). Secondly, avatar reactions to student emotions were implemented following the instruction coming from an experimental group of students, as explained in the following paragraph.

3. Project description

In all the papers reviewed in the state of the art, the suggested approach is top down rather than bottom up. In fact the majority of the papers in this field starts from the theoretical study of the emotion, trying to find the best schema in the psychological field (that could be dimensional rather than categorical) and shift this schema in an engineering framework using sensors to catch the real time emotions. That approach, even if very interesting and challenging, is not the one used in our project. In fact, concerning the emotional interaction with students, we started from the bottom, by asking students to investigate their feeling in school context. With an experimental group of students, we have worked on emotions, starting to analyze what they feel during real school scenarios, like a test session or an oral presentation. Students filled a form expressing the range of emotions that they have experienced during real test sessions. Then, for each emotion they express a *wished* behaviour of the virtual tutor (Pedagogical Agent), a *motivational phrase* of the tutor, and the *facial expression* that the tutor should have; for the last purpose we used the work done in the field of facial recognition (Johnston 2008) to model the agent facial expressions in a sort of reverse engineering process. The work done whit the experimental group of students is deeply described in Section 3.1.

All the collected emotions have been registered in a database linked to a possible reaction of the virtual tutor, namely a facial expression and a motivational phrase that is a preregistered animated agent. Students interact with the IPA via chat expressing their feeling in natural language. Natural language analysis is then performed on students phrase to detect heir emotion. Then the IPA provides the best answer to the student according to a specific algorithm. This part is described in Section 3.2.

3.1 Building the emotional IPA

The approach that we have followed in this project is depicted in Figure 3**Figure 1**: we have decided to study students emotions during real school situations as well as to analyze emotions theoretically with students. We collected all the data coming from the students and used them to model and implement the IPA. The reasons for doing that have been several. We have decided not to use sensors that could detect emotions in real time because our Serious Game is conceived as a support tool for teachers that should be used in real classroom sessions and thus should be easy to use: students must feel confident and emotionally safe. Secondly the game is rather *slow*, need reasoning and time to provide solutions to the proposed quests, thus the engagement of the student is not concentrated in a short period of time in which the game should react to a specific emotion (student should not shoot monster and increase their adrenaline like in a commercial game). As a consequence the emotional path implementation is focused on the creation of a trusted relationship between the student and her virtual tutor, the IPA: “social intelligence in pedagogical agents may be important not just to gain user acceptance, but also to increase the effectiveness of the agent as a pedagogical intervention” (Shen 2009). Finally, the strength of our approach is the collection of results coming directly from the students/stakeholders that reduce the risk to model the IPA in a way that is not fascinating at all for the students themselves basing just on complex psychological models.

The work done with the high school students has not involved the Artificial Intelligence layer of the animated agent that have been added in a second development phase by our research team, as described in Section 3.2.

Since the beginning of the project students have worked with an excel form like the one reported in Figure 4.

Each student has her own form and should fill a specific column of the work sheet as output of each lesson, as it will be explained in the next paragraphs. The following table is a summary of the activities carried on with the students in the time slot of the project.

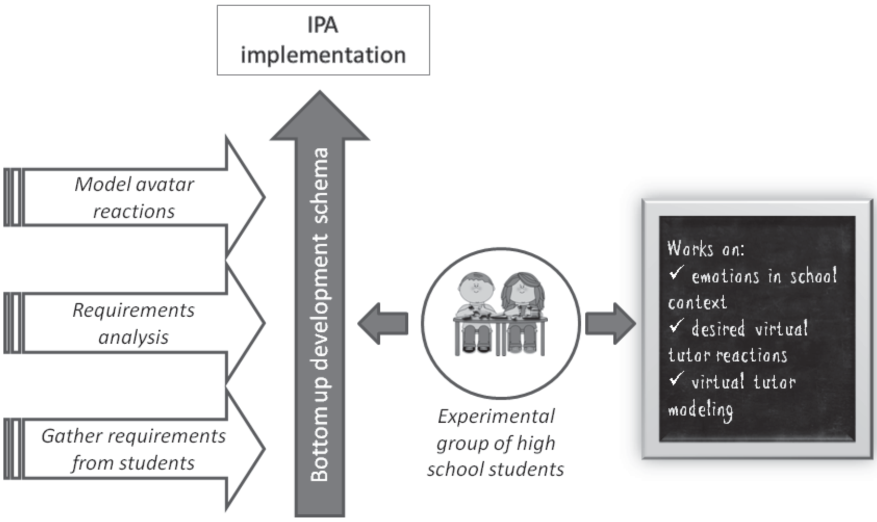
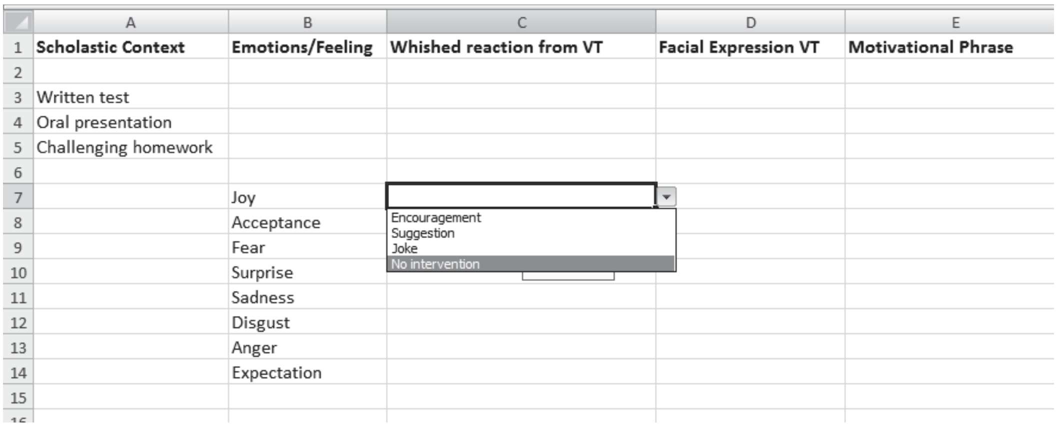


Figure 3: Design and development schema

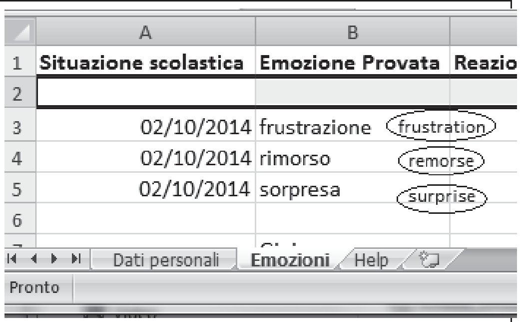
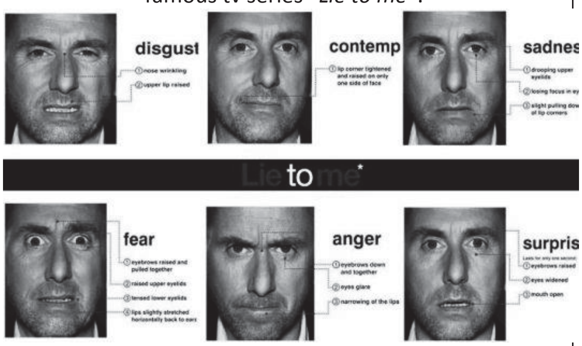


	A	B	C	D	E
1	**Scholastic Context**	**Emotions/Feeling**	**Whished reaction from VT**	**Facial Expression VT**	**Motivational Phrase**
2					
3	Written test				
4	Oral presentation				
5	Challenging homework				
6					
7		Joy			
8		Acceptance	Encouragement Suggestion Joke No intervention		
9		Fear			
10		Surprise			
11		Sadness			
12		Disgust			
13		Anger			
14		Expectation			
15					

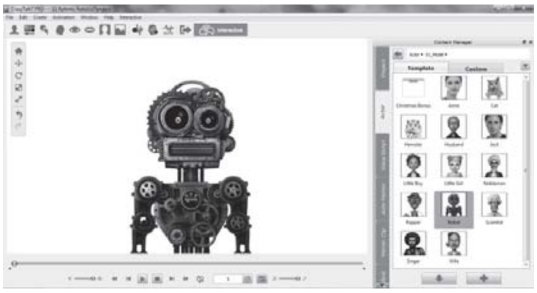
Figure 4: Student form

Table 1: Students project work plan

Single class schedule	*110 minutes*	**School Grade**	*8th*
Number of students	*20*	**School Subjects**	*Literature/Informatics*
Number of lessons	*7*	**Project timeslot**	*3 months*
Lesson	**Teacher activities**		**Student activities**
N° 1 17/09/2014	During the first lesson we have presented the project to the students and we have explained some concepts related to games, virtual tutoring, animated agents and artificial intelligence. In this way students were able to understand the context in which the project was placed. We did not yet mentioned anything about emotions.		Two students of the group were involved in a written test situation. At the end of the test students expressed their feeling and emotions. The students not involved in the test were committed to describe facial expression of their classmate.
N° 2 02/10/2014	In this second lesson we have presented to the students the form in Figure 4. We explained the meaning of each column of the form and we mainly explained and discussed basic emotions starting from the hereafter schema proposed by Lane, Nadel 1999.		At the end of the lesson students were asked to do a literature test without notice. The test was of medium difficulty and was about some topics explained few days before by the teacher. At the end of the test students filled the form we provided, each one with her own feelings. We left students the freedom to express freely without taking into account the emotions already explained.

<table>
<tr><td>Single class schedule</td><td colspan="2">110 minutes</td><td>School Grade</td><td>8th</td></tr>
<tr><td>Number of students</td><td colspan="2">20</td><td>School Subjects</td><td>Literature/Informatics</td></tr>
<tr><td>Number of lessons</td><td colspan="2">7</td><td>Project timeslot</td><td>3 months</td></tr>
<tr><td>Lesson</td><td colspan="3">Teacher activities</td><td>Student activities</td></tr>
<tr><td></td><td colspan="3">
</td><td>
</td></tr>
<tr><td>N° 3
16/10/2
014</td><td colspan="3">In this lesson we continued the work on emotion reading some literature texts and having free discussion among students. We also project some video taken from Italian movies about everyday school life in which students and teachers were in exasperated and paradox situations in order to stimulate the students reasoning about the relationship with teachers.</td><td>Students filled another column of the provided form. For each one of the eight basic emotions identified in the previous lesson, students were asked to express the wished behaviour of a virtual tutor, namely the agent. Together with the students we limited the possible reaction of the agent to four (thinking at the future implementation of the agent and remaining on a discrete world):
Encouragement
Suggestion
Joke
No intervention</td></tr>
<tr><td>N° 4
30/10/2
014</td><td colspan="3">In this fourth lesson we discussed about emotions and corresponding facial expression. In order to make the topic funnier we used some materials coming from the famous tv series “Lie to me”.


We invited to this lesson a professional dabber to work on pitch and facial mimics.</td><td>Students were invited to perform a psychology test in which they should recognize the emotion expressed in a picture. The test was online and interactive. Students were asked to answer the test all together favouring brainstorming and constructive discussion about emotions and facial mimics.
In addition they filled another column of the form in which they should invent a phrase that the agent should say in each specific student emotional state and based on the already expressed wished behaviour of the agent (encouragement, suggestion, etc).
At the end of this lesson each students has her form fully filled and ready to be use in the upcoming implementation phase of the project.</td></tr>
</table>

<table>
<tr><td>Single class schedule</td><td colspan="2">110 minutes</td><td>School Grade</td><td>8th</td></tr>
<tr><td>Number of students</td><td colspan="2">20</td><td>School Subjects</td><td>Literature/Informatics</td></tr>
<tr><td>Number of lessons</td><td colspan="2">7</td><td>Project timeslot</td><td>3 months</td></tr>
<tr><td>Lesson</td><td colspan="3">Teacher activities</td><td>Student activities</td></tr>
<tr><td>N° 5
28/11/2
014</td><td colspan="3">The CrazyTalk tool has been presented and explained to the students.
</td><td>Students freely used the already explained tool in order to get familiar with it. They tried out different functionalities of the tool like: agent creation, agent animation, registering phrases, etc.
</td></tr>
<tr><td>N° 6
07/12/2
014</td><td colspan="3">Teachers asked the students to fill a very simple questionnaire about the agent they would like to have expressing some desiderata like: should be human or not, should resemble you or someone that you know, should be fantasy or really existed, etc.</td><td>During the last two lessons students were grouped into group of two and started creating their personal agent using the form they already filled with emotions and phrases to animate the character they have chosen.</td></tr>
<tr><td>N° 7
12/12/2
014</td><td colspan="3">In this way teachers collected results about the physical aspects of the agent. Results are reported below</td><td></td></tr>
</table>

The outcome of the study has been a collection of emotions linked to real scholastic situations plus a collection of motivational phrases and mimic expressions of the potential IPA.

From the study emerged that the majority of the students (80%) feel disgust and fear as first reactions to a school test followed by acceptance and very rarely joy or anticipation. It is very rare that a student feel a positive emotions during this kind of situation and very often frustration shows up. That is why the majority of the students (80%) expressed the desired to be encouraged by the IPA with motivational phrases that could help them to exit from this emotional state. Example of motivational phrases given by the students are: *1) Nothing is impossible, take your time! 2) You know, life is full of surprises… 3) First think and then act! 4) Keep it easy, it will get better. 5) Try to let it get pleasant. 6) Patience is a virtue. Studying a bit more you can increase your strength and patience as well. 7)Next time it will be different. 8) You can do it!*

A minority of students (25%), in certain situations, wish to interact with the IPA via funny (joke) phrases like: *1) You will get a C anyway (winkling) 2) What the hell did you do? No, I am kidding. You have been so incredible!3) I will be frustrated if you don't like it!* In this way students feel that the study get less boring and that is possible to establish a positive studying environment.

Finally it is worth noting that some students (30%) do not wish any intervention by the IPA especially when they are concentrated and feel confident about what they are doing. In such situation they feel the interaction with the IPA as a disturb. This result matches with the one obtained in the study from Johnston mentioned in the state of the art.

The results of the questionnaire about the aspect of the IPA showed that the majority of the students wished to have a human like avatar, possibly a really existed character like a famous scientist or an historical character (e.g. Albert Einstein, Giuseppe Verdi). Science fiction also revealed to be an important source of inspiration, emerging character like Irobot or Doctor Who.

3.2 Building the IPA packed as an android application

On top of the results coming from the study previously described, it has been built an Android application that uses the IPA as interlocutor while studying STEM subject. At this stage of our research project, the Serious Game is still under development and thus we have decided to test the IPA building a standalone application. Once the Serious Game will be almost ready the IPA will be fully part of it.

The application works as it follows. The student registers to the application via Facebook or simply registers by filling a form. Once she is logged, she can choose among a list of topics and available IPAs (with different aspects). Once the topic has been chosen, students can chat with the IPA simulating a natural dialogue about the topic covering pedagogical and learning aspects.

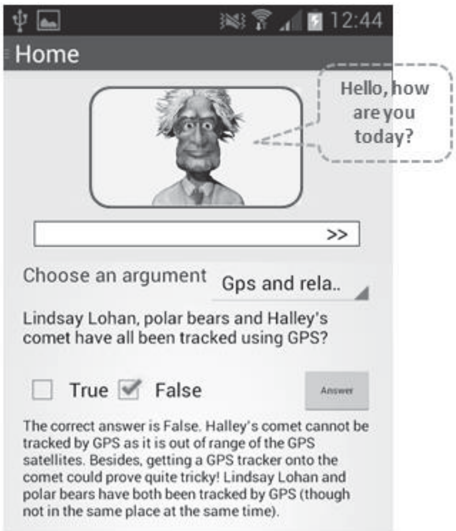


Figure 5: Screenshot of android application layout

The system allows the user to freely express her thoughts in textual form. The IPA is able to guess student emotions by exploiting a Web service (using a natural language toolkit) that analyzes the sentence and returns an emotional state. The user gets back an adequate answer selected from a database filled with the collected emotions from students (outcome of the previous phase of the study) and expected corresponding motivational phrase. Each possible answer corresponds to a pre-registered mp4 file in which an animated avatar has been modelled following the instructions given by the students in the previous phase of the study (mimic expressions and motivational phrases). Beside the emotional relation between the student and the IPA, the student is able to chat with the IPA about the subject of study that is explained via textual message. Even if in this work we focused our attention on emotion, the possibility to chat with the IPA about discipline aspect is fundamental as well and is based on the same idea to gather the best answer to learning questions via AI algorithm.

Table 2: Use case description

Steps	Description
Register	The student register into the application providing her data (that will be used for statistical purpose)
Choose an IPA	During the registration phase the student can choose an avatar that correspond to a physical character. The application starts and the avatar welcome the student and asks about some personal data (simple question like 'How are you today'). Student replies and her sentence is analyzed by a web service that perform a sentiment analysis. The avatar replies depending on the detected mood of the student.
Choose a topic	The student selects a topic from a list and choose an argument. Some explanation in text format appears. The avatar interact with the student asking if the text is clear or if other explanations are needed, if other explanation is needed more content is provided.
Ask a question	The student can also ask a free question to the avatar. The answer should be both emotionally safe (empathy with the student) and pedagogically correct.
Solve test	The proposed explanation are interspersed with test/quiz that the student should solve. Depending on the student answer (correct or wrong) there is a reaction of the IPA (e.g. *congratulations very clever*, or *ups it will get better next time*)
Ask clue	If the student is not sure about the correct answer can ask clues to the avatar.
Collect and analyze data	Data are collected and at the end of the study session the student get a score depending on her correct/wrong answers.

Figure 6 represents the overall schema of our application in which the main parts are depicted: a natural language Web service is used to analyze student sentence; an AI algorithm get back the best answer from the populated DB.

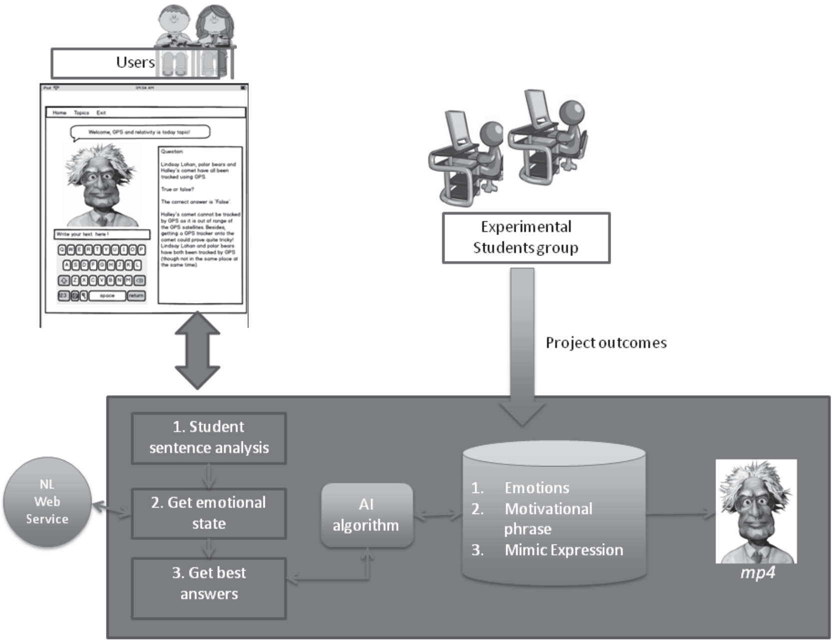


Figure 6: Android app schema

The used DB schema is represented in Figure 7.

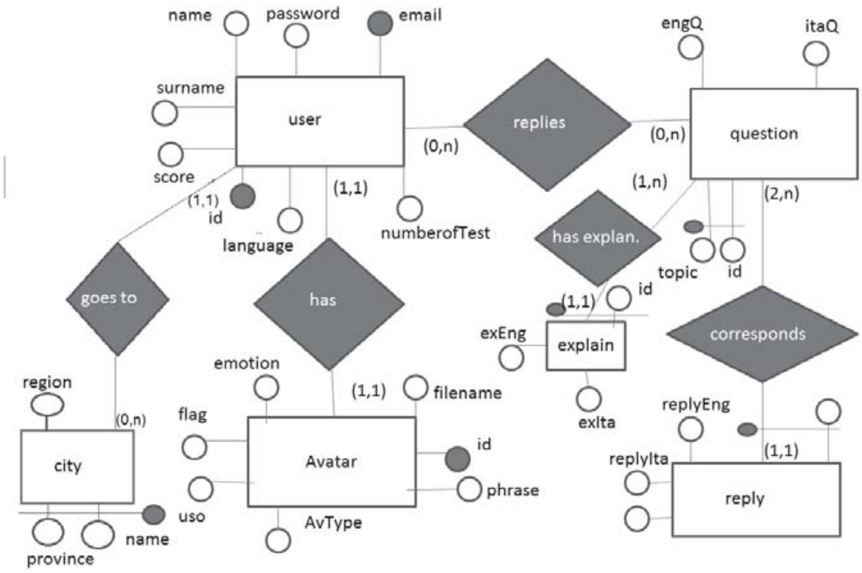


Figure 7: Application DB schema

Actually we use a very simple service to analyze the student sentence both concerning the emotion and the learning aspects. In a near future we will use the natural language analysis according to the approach proposed by Mori (2013). That system is a Dialogue Management System, which manages dialogues where the user has the ability to interact in natural language with the virtual tutor in a more sophisticated way: the communication is implemented through an NLP algorithm based on an ad hoc text retrieval problem solver and on a Naive Bayes text classifier with an inner product-based threshold criterion. Actually we just work on a keywords based discovery systems.

4. Future work and conclusion

In this proposal we do not use real time detection of emotion based on audio and video sensors but we use a database filled with the outcomes of an experimental approach based on real students emotions studying. This approach can be viewed as an effort in the direction of filling the lack of research efforts in detecting emotions during learning in real-time (Shen, Wang, Shen 2009): "Future studies should explore how to leverage the affective information into the new pedagogical strategies. For example, at which emotion states will the learners need help from tutors and systems (when they are confused or frustrated)? What kind of help do they need at a specific emotion state?". In our study we replied to those kind of questions directly working with students in real school scenario. The strength of this approach is the collection of results coming directly from the students/stakeholders that reduce the risk to model the IPA in a way that is not fascinating at all for the students their selves. In this paper we have showed what we have done so far with a class of 20 students. One of the main follow up of the study will be to enlarge the audience of students in order to have more reliable results: we want to replicate this school study in order to collect more feedbacks.

For what concern the technological aspect of the study we plan to refine the application working on two main paths. First of all we should reinforce the Artificial Intelligence algorithm that is beyond the natural language dialogue simulation. We are already working on this direction and we will soon integrate the DMS proposed by Mori.

Secondly future effort will be put in the development of an authoring tool: each teacher will be able to provide personalized contents for the android app (covering different topics, not necessarily STEM subjects) decoupling the database population (implementing an authoring tool via a web service) from the application itself. In this way teachers can benefit from the usage of our IPA teaching their ad hoc content.

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Developing an Epistemic Game: A Preliminary Examination of the Muscle Mania© Mobile Game

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Abstract: Several game scholars contend that the traditional understanding of vocational education in terms of curriculum content only is insufficient.Instead, they propose that lecturers need to develop a system in which students learn to think and work as reflective practitioners through an epistemic frame that mimics the real-world to allow students to have rich experiences of their domain-specific subjects. The Framework for the Rational Analysis of Mobile Education (FRAME) model offers some insight into the development of an epistemic frame within a mobile device.In particular, it extensively links the hardware, software and connectivity options to meets with learner's cognitive, physical and psychological needs in the context of their learning environment.In this model, the mobile device is an active component and the mobile learning experiences are viewed as existing within the context of information that is mediated through technology. The aim of this paper is to explore the efficacy of using Muscle Mania© as a mobile platform. Arguments for implementing mobile-learning within higher education have generated an increasing volume of research. The general focus of these studies, however, is based largely on empirically documented work with little theorisation on the design of mobile games.In the pursuit of using mobile technology to develop an epistemic or discipline-specific game that will facilitate the teaching and learning of the muscles of mastication and facial expression, this paper explores the FRAME model and how it can be used as a substantive theory for mobile-learning. A qualitative research design and a case study strategy were adopted.Data was collected by means of reflective reports on the mobile game prototype from the technical designer, lecturers and students. With its strong emphasis on educational software design, the Device Usability Aspect of the FRAME model guided the internal architecture needed to design the epistemic frame of a mobile game. Equally significant, the FRAME model foregrounds the concept of techno entrepreneurship as it demonstrates how lecturers use technology to move from delivery and supervision to the production of knowledge.

Keywords: android SDK; muscles; epistemology; debriefing; FRAME model

1. Introduction

The evolution of wireless technologies and game applications on mobile devices has facilitated mobile learning.Subsequently, this is diversifying the higher education teaching and learning milieu.In particular, and as Traxler (2009) asserts, mobile devices are "changing the nature of knowledge and discourse…whilst being themselves the products of various social and economic factors".He, along with several other game scholars (Ally, 2009, Rupp *et al.*, 2010, Caperton, 2010, Ferran-Ferrar *et al.*, 2014), posit that mobile learning supports authentic and context-specific learning that involves real-world problems by situating and connecting learners, particularly in distant learning programmes.Shaffer (2005) also argued that lecturers need to develop a system in which students learn to think and work as reflective practitioners through an epistemic frame. According to Shaffer and Gee (2005) an epistemic frame is a mechanism that mimics the real-world in order to allow students to have rich experiences of their domain-specific subjects. A corollary to this is an epistemic game, which provides students access to a particular form of thinking by enabling them to connect knowledge-in-context to knowledge-in-action.Shaffer and Gee (2005) elaborate that epistemic games facilitate the emergence of disciplinary thinking and acting which can also be transferred to other contexts. Consequently, it can be inferred that students are more likely to develop domain-specific expertise under realistic conditions.

Equally important, and as Shaffer (2005) maintains, games "make it possible for students to learn through participation in authentic recreations of valued reflective practices – a new model of learning for an era of dramatic social and economic transformation brought about by new technology".While there are arguments to implement mobile games within higher education (Ally and Tsinakos, 2014, Gupta and Koo, 2010), there is limited research work on a structured and comprehensive approach used to develop mobile games aimed at enabling students' access to, and acquisition of, discipline-specific knowledge.This paper reports on the software architecture and the technical aspects of the Muscle Mania© mobile game, which builds on the previous version of the digital game.In particular, and for 95 students who played the digital game over a three-year period, statistical analyses showed that their performance in tests improved(Vahed, 2014).The most noteworthy feature in Table 1 is the direction of the differences in student performances, particularly the mean values of the pre- and post-test results.The 2-tailed t-tests revealed that students' performance improved significantly after playing the Muscle Mania© digital game ($p < 0.05$). Consequently, this provided the impetus to transform the digital game into a mobile game, especially in light of what is considered as the mobile age, or the mobile technical revolution (Traxler, 2009, Ferran-Ferrar *et al.*, 2014), of higher education. From an instructional design perspective, the task of re-designing discipline-specific content for the mobile phone was not required.It is, however, necessary to briefly describe the Muscle Mania© digital game in order to understand differences of software designing for mobile applications.

Table 1: Improvement of student results

Muscle Mania©	2009	2010	2011
Mean: Pre-test	36.04	31.94	56.48
Mean: Post test	48.35	60.41	70.52
p-value	0.000	0.000	0.002

The computer application of the Muscle Mania© game used Macromedia® Flash™ technology (Figure 1) to provide high-quality animations and to deliver flash objects across different screen resolutions.Macromedia® Flash™ technology also provided realistic ways of delivering complex muscle concepts in one computer application. To facilitate game speed and the automatic allocation of marks, the game was designed around multiple-choice questions, which centred on the structural and functional anatomy of the muscles of mastication and facial expression. The student's progress in the game is measured in terms of achieving the highest score.If students score 100%, they enter the *HOT* zone (Figure 2). If they score 80% or more they enter the *TWILIGHT* zone, and if they score less than 80%, they enter the *ICE AGE* zone. The objective of the game is to enter the *HOT*Zone, where three different skull images are displayed.The student is required to move the various muscles to the rightful place on the skull.Consequently, this reinforces the anatomical knowledge learnt during game play.It is worth noting that the Twilight zone offers movement of the muscles in the frontal view of the skull only (Figure 2).The Ice Age zone offers no rewards to the student.There are two different action sounds in the game, namely one to inform the player when he/she correctly answers a question, and another when answered incorrectly.As described by Ruggill *et al.*(2005), including sound in the game enriches and vivifies the visual landscapes and action sequences they accompany.

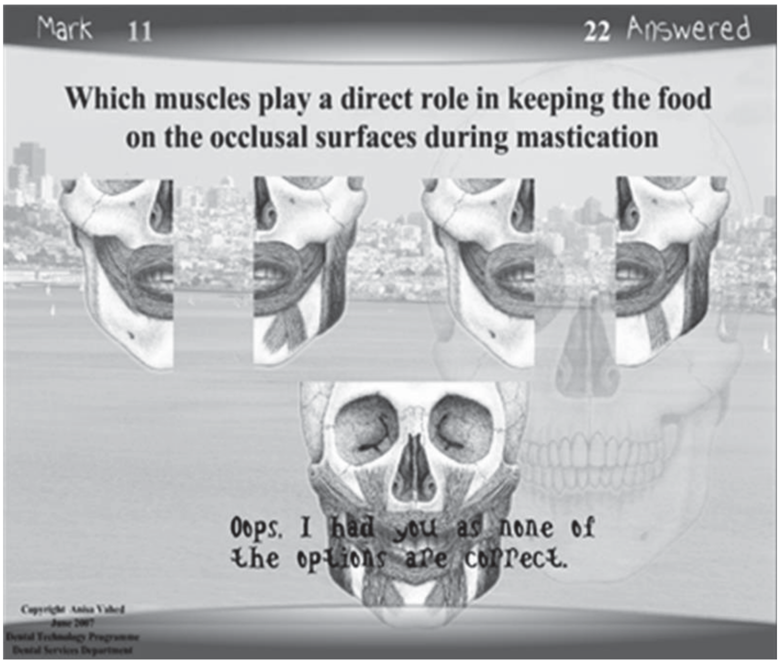

Figure 1: Macromedia® Flash™ technology

Significantly, the lessons learned from the technical design of the digital game compares with the literature on the software design of mobile technology.For example, and as outlined by Rekkedal and Dye (2009),mobile technology must be user-friendly and the graphics used must be compatible with the mobile software.This means the graphics must be of an acceptable quality and easy to navigate to enable the experience of learning through mobile technology.This paper therefore aims to explore the efficacy of using Muscle Mania© as mobile platform.

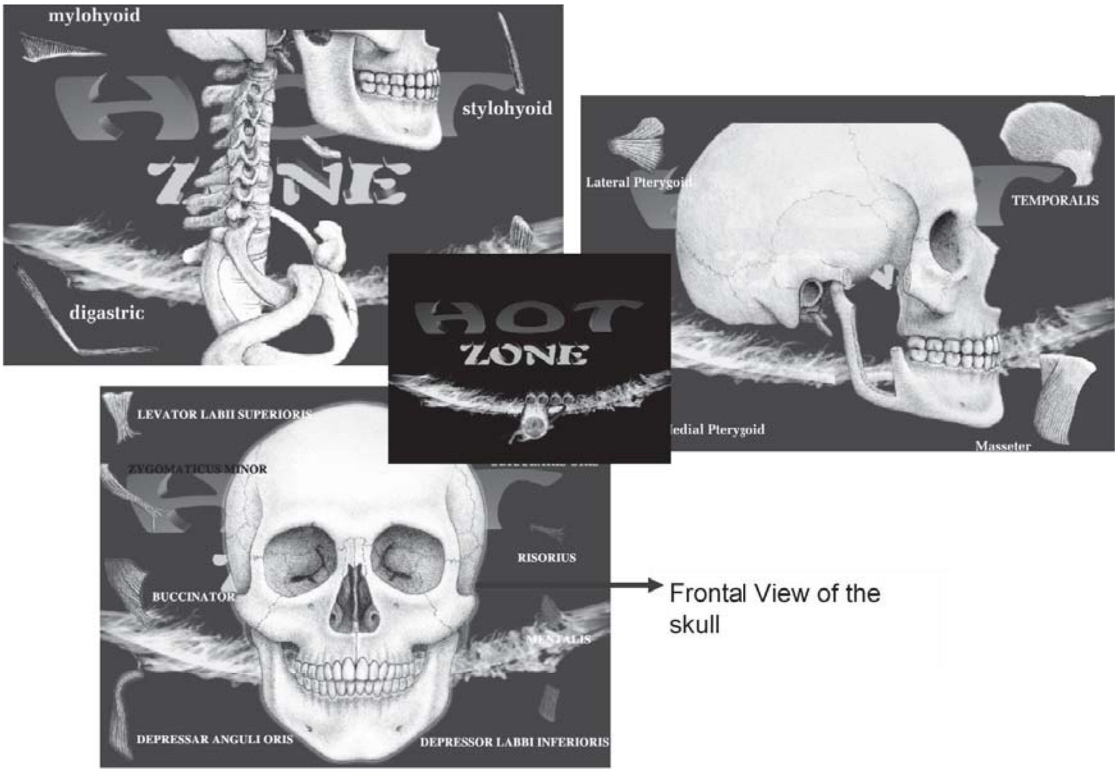

Figure 2: Screen snapshot of Hot Zone-Muscle Mania©

2. The software architecture of the Muscle Mania© mobile platform

Android provides a rich application framework to build innovative apps and games for mobile devices in a Java language environment. Essentially, using a Java programming language means that the programme can operate on multiple platforms through the Java Virtual Machine (JVM).From a software design perspective, Android platforms provide easy data sharing between apps and supports interoperability between apps.Such frameworks and technologies can integrate to enable access to hardware and software features on the device and to some user-specific information like the location of the device(Müller and Dikke, 2012, Ring, 2013).Hence, the Android software development kit (SDK) was used to develop the Muscle Mania© mobile game (March – June 2014).Android SDK is part of the open source community, enabling anyone to develop their own applications and market them through Google play. In particular, Android SDK also allows developers to modify and customise the operating system (OS) for each phone; especially as different Android-based phones may have different graphical user interfaces (GUIs) even though they use the same OS. A deployment view of Muscle Mania is shown in Figure 3.More desirable colours were used and icons were added to provide easy access to game features. In contrast with the digital game, in the mobile game the player scores ten points for every correct answer.If the player chooses to scratch the image for a clue to answer the question, two points will be deducted per scratch made. Scores are automatically recorded and are displayed for the player to track their own progress during game play.The action sounds for answering correctly and incorrectly were also changed.Similar to the digital game, success in the mobile game is measured by linking scores to performance zones (HOT, TWILIGHT and ICE AGE).

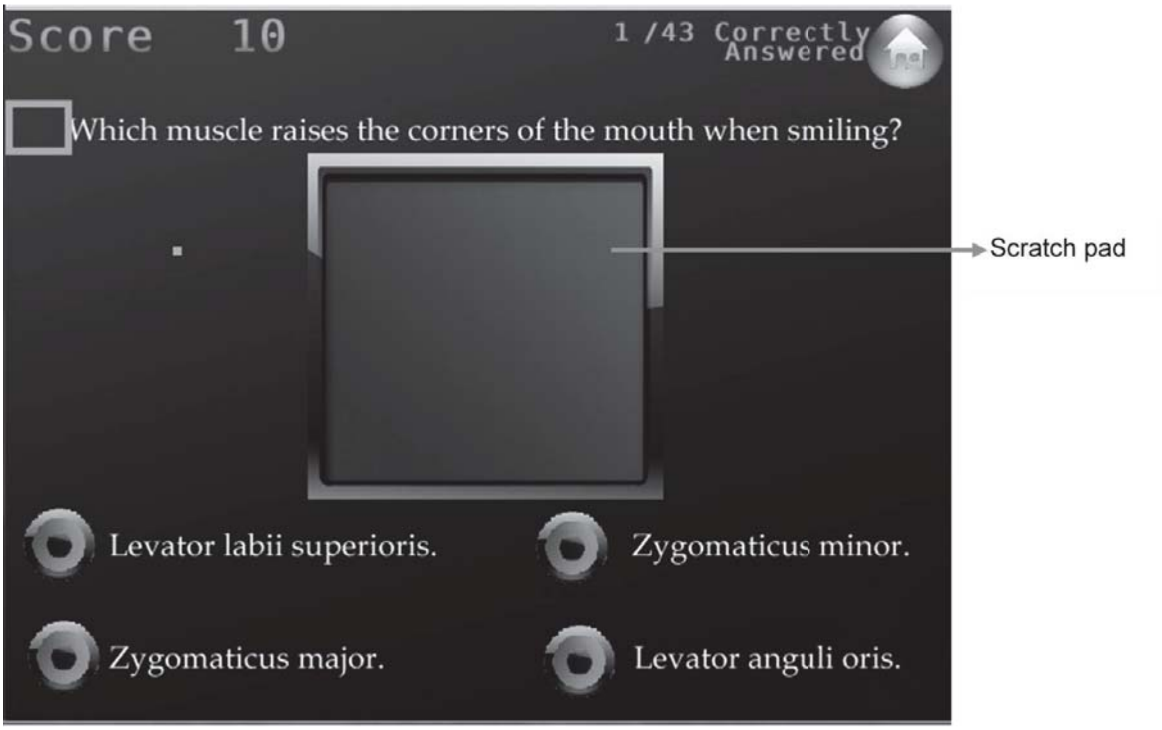

Figure 3: A print screen shot of the Muscle Mania© mobile game

3. Methodology

Several studies (Ally, 2009, Ally and Tsinakos, 2014, Hodgekinson-Williams and Ng'ambi, 2009, Wang *et al.*, 2007) indicate the potentialities of using mobile phone technologies to promote higher levels of student engagement in learning; support the transmission and delivery of rich multimedia, and interactive content; support meaningful, context-specific and immediate learning (situated learning); and provide authentic learning experiences where learning involves real-world problems.There is, however, a need for more rigorous reporting on the educational software design of discipline-specific mobile games.This research therefore sought to use a case study research strategy (Remenyi, 2013) to aid an in-depth exploration into educational software design of the Muscle Mania© mobile game.This approach is strongly associated with qualitative research as it aims to holistically "understand the case in depth, and in its natural setting, recognising the complexity and its context" (Punch, 2014).

Using their own mobile android-based devices, the 2014 B Tech:Dental Technology students and Dental Technology lecturers volunteered to play the game prototype. The participants were provided with the software, which was loaded onto their devices prior to playing the game. Data was collected by means of reflective reports from the technical designer, the 2014 Degree of Bachelor of Technology (B Tech) Dental Technology students (n=5) and dental technology lecturers (n=4) who played the mobile prototype on the 5 August 2014 using their own android-supported cell phones.In turn, they provided feedback reports on their experiences of playing the mobile game. A week later another test session was conducted (12 August 2014) with the same test users, in order to determine whether the changes had improved the mobile prototype overall.A two-stage data analyses followed.

The first stage involved analysing the feedback from the reports in relation to Koole's (2009)Framework for the Rational Analysis of Mobile Education (FRAME) model.As illustrated in Figure 4, this model consists of a three-circle Venn diagram comprising the intersection of three fundamental aspects, namely: device, learner, and social.The device aspect focuses on the physical, technical and functional characteristics of a mobile device. The learner aspect describes how learners use their knowledge and how they encode, store, and transfer information. The social aspect of FRAME considers the processes of social interaction and co-operation.These aspects intersect to form sub-aspects in device usability, social technology, and interaction learning.The Device Usability (DL) intersection connects characteristics of mobile devices to cognitive tasks related to manipulation and storage of information. The Social Technology (DS) intersection focuses on how mobile devices enable communication and collaboration amongst multiple individuals and systems. The Interaction Learning (LS) aspect describes how learning is collaborative with meaning negotiated from multiple aspects. The mobile learning intersection (DLS) is the culmination of all the characteristics of the aspects and intersections.

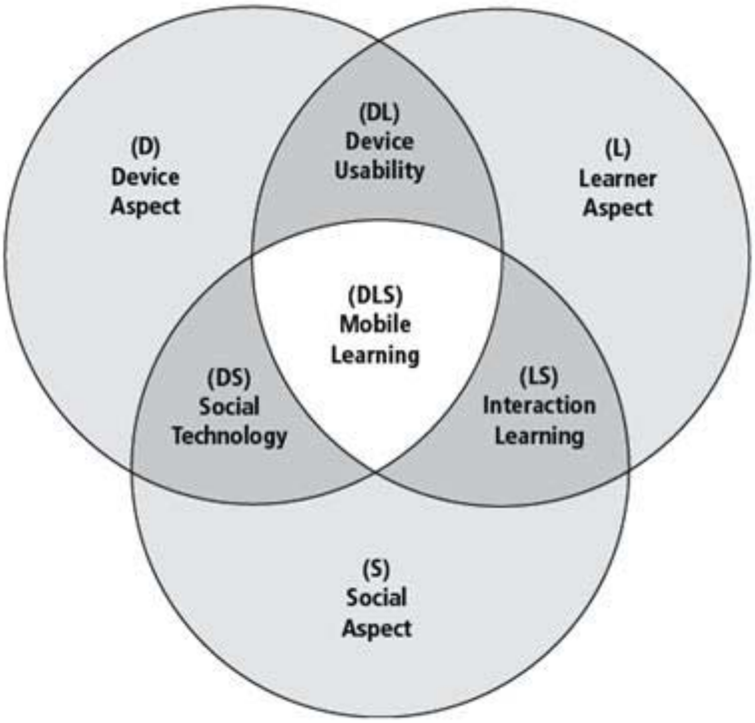

Figure 4: FRAME model (Koole, 2009)

This paper centres on the device usability (DL) aspect, only.As described by Koole (2009), DL "bridges the needs and activities of the learners to the hardware and software characteristics of their mobile devices".Potentially, this interface significantly impacts on the physical and psychological comfort levels of the user.

In the second stage of the analysis, the findings of stage one were assessed in terms of being compliant with the principles of the technical design frame of the Knowledge/Instructional, Technical and Educational (KITE) framework(Vahed, 2014).The criteria of this frame relates to:

- Synthesis of the game mechanisms (graphics and other multimedia materials) with the device software.
- Debriefing: this is a platform to share ideas (Crookall, 2010), which in turn legitimately enriches learning throughout the software developmental stages.This is significant when discipline-specific lecturers are part of the design team in evaluating the different stages of the software development process.
- Intellectual property: From a legal perspective, this knowledge guides the protection of the game design.This is an integral component of the frame particularly from the perspectives of introducing the game in mobile platform, or in legal terms the intellectual property, to the business world. This is significant in moving educational mobile games to quality levels of pedagogical validation beyond perceptions that they are purely for entertainment.It is worth noting that the design and artistic work of the Muscle Mania© game is copyrighted and a trade mark application has been filed through the Intellectual Property office of the Durban University of Technology (DUT).

The KITE framework critically foregrounds that careful consideration of the aforementioned elements is fundamental to the design of quality educational games, that is, they must be valid for the full range of purposes for which they are intended. Trustworthiness of the data was achieved using peer debriefing (Crookall, 2010), methodological and data triangulation (Somekh and Lewin, 2011).

4. Findings and discussion

Feedback from lecturers and students was replete with positive comments on the user interface and execution of Muscle Mania© as a mobile platform.They uniformly claimed that the software design provided "…clear sounds and graphics."thereby making Muscle Mania© "…easy to read and understand."This finding is consistent with Gee's (2007) concept of situated learning as the mobile platform enabled lecturers and students to situate meanings related to the muscles of mastication and facial expression in an active and critical way. No mention was made to the size of their mobile screens, so we assume that no-one had concerns with it.Significantly, and through debriefing sessions after playing the Muscle Mania© mobile game, lecturers and students generally agreed that the game was clear and sufficiently bright on their mobile screens.As illustrated in Figure 5, they also pointed out that the colour, text type and text size displayed made Muscle Mania©legible.In relation to the DL aspect of the FRAME model(Koole, 2009), the positive comments received from the lecturers and students indicated that they were comfortable in playing Muscle Mania© as a mobile platform. This ease of use enabled them to focus on cognitive tasks rather than the device itself. The aforementioned findings are also compliant with the principles of the technical design frame of the KITE framework.

Figure 5: Mobile screen shot of Muscle Mania©

Regardless of the positive comments, weaknesses in the software design were identified in terms of contextual cues.The negative comments are given verbatim: "Think questions should be numbered."; "For revision purpose, I think the game should pop-out the right answer if the student got it wrong."; Need an option button to go back to the previous question".; "I think there needs to be an indication of which question is being answered correctly".; and "Number the question you are on."In relation to the last two comments above, this was corrected and is illustrated in Figures 3 and 5.In debriefing sessions, lecturers critically pointed out that the muscles in the HOT zone "goes back to the original position if placed incorrectly" or "… it will let the game place if for you."As advised by one lecturer, this can be corrected by introducing a "…double click to attach muscles".This will be considered when improving the software design of the game in the future.

In the early phases of developing the mobile game, debriefing sessions between the discipline-specific lecturer and computer programmer helped to identify connections between the visual and contextual cues. For example, compatibility of the multiple-choice questions with the software design was analysed in terms of appropriateness and clarity. This is evident from the verbatim comment below:

> *"…In the early phases she(discipline-specific lecturer) and I (computer programmer) had a fair amount of meetings in regards with discussing which questions to reuse and how to rephrase the old questions to keep the user/player to challenging themselves and what new questions to create and include."*

Essentially, the interaction between the discipline-specific lecturer and computer programmer complies with the principles of the technical design frame of the KITE framework.

While educational game design is a form of what Squire and Jenkins (2003) call "social engineering", educational software design can arguably be recognised as 'techno-social engineering' as it enables the interweaving of different software mechanisms (game and mobile) intended to support learning through social interactions. The findings of this paper revealed that educational software design which is guided by the principles of the FRAME model potentially enabled discipline-specific lecturers to improve what they are actually doing as opposed to imposing changes to what they do. Equally important, having achieved a refined working prototype could promote Muscle Mania© through Google Play store.This is area for further research.

5. Conclusions and recommendations

Overall, the salient features of this paper show that educational software design can leverage meaningful mobile design by providing richer and more supportive guidelines in making discipline-specific content accessible through mobile devices. This is particularly significant in a climate where mobile connected technology is becoming increasingly ubiquitous, and is being heralded as important in helping students to understand the relevance of work-based learning and the need to acquire specific skills of immediate value for professional practice. Herein lies an area for further research, particularly in terms of sharing and disseminating information on teacher-led innovations that use mobile technologies in higher education.

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Analysing the Enjoyment of a Serious Game for Programming Learning With two Unrelated Higher Education Audiences

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Abstract: Serious games are generally considered a good alternative to improve motivation to learn. A game should have meaningful mechanics and elements to involve the players and to keep their attention. Each person has his own motivation to play games. This leads to different types of players and consequently to the need of different types of elements to keep them engaged. Understanding the player's behaviour is an important issue to improve support in the game. While the designer of a serious game focus mainly on its educational value, it is also important to incorporate fun elements in the game. We are developing a serious game aimed to help the development of basic computer programming skills. Our challenge is to create a game that provides effective self-learning support while keeping the student engaged in the game's missions. This paper deals with the game features and their evaluation. The game has missions covering basic concepts of computer programming: sequence of actions, variable manipulation and conditionals. In this research, we are concerned with evaluating the game enjoyment. We conducted two experiments with groups of students from completely distinct knowledge areas. First, we applied the game in a Portuguese Education Sciences class that included essentially female students. Next, we performed a play test in a Brazilian first semester of Software Engineering undergraduate class composed essentially by male students. We believed that we would identify a larger set of needs if we diversified the types of players that tried the game. Consequently, if the game satisfies their needs, we would reduce the possibility of failure of the game. The EGameFlow instrument was used to measure the enjoyment. Findings show that the game entertains the players even if the programming tasks are hard. However, some improvements are necessary to foster self-learning. Finally, the paper presents future work that aims to include new challenges and missions in the game and to improve the enjoyment.

Keywords: computer programming, serious game, educational game, enjoyment, programming learning

1. Introduction

Research stated a number of factors in serious game design that contribute to enhance the learning outcome, as fantasy elements and novel task types (Ronimus et al. 2014), intuitive controls and progressive difficulty(Mckernan et al. 2015) and adaptive learning content according to the player learning style (Soflano et al. 2015). These examples and many others factors in the game-based research aim to identify practical guidelines for game and instructional designers achieve the flow state in their games. Flow is an experience "so gratifying that people are willing to do it for its own sake, with little concern for what they will get out of it, even it is difficult or dangerous" (Csikszentmihalyi 1990). Enjoyment feeling maintains the people attention and engagement on the activity. Enjoyment is central to computer games (Sweetser & Wyeth 2005; O'Neil et al. 2005) and is helpful to learning, as positive affective experience can improve learning outcomes (Pavlas 2010).

Learning programming is difficult (Gomes & Mendes 2007) and there are many serious games dedicated to support it.Vahldick et al. (2014) presents an analysis of such games and identifies some gaps. This paper presents No Bug's Snack Bara new serious game designed to support programming learning. After a first version of the game was created, we wanted to know if the students would find it enjoyable. This paper presents experiments involving two groups of students to measure how enjoyable the game is using the EGame Flow instrument (Fu et al. 2009). Each group has completely different characteristics from the other: knowledge area, country, genre and age. We assumed that involving two very different groups would allow us to reach wider views about the game and, maybe, more diverse input about it.

The following section describes some related work that served as inspiration for some aspects of our work. Section 3 describes the enjoyment measurement instrument used in our work. Section 4 presents the game mechanics and its elements. Sections 5 and 6 describe the research questions and the methodology used in our research. Section 7 presents and discusses the results obtained. Section 8 adds some notes about limitations in this research to suggest further work. The paper concludes with a summary and some ideas for future work.

2. Serious games for programming learning

Vahldick et al.(2014)listed 40 serious games intended to promote learning of programming. The authors divided these game sin three types: LOGO-like, adventure games and general puzzles. LOGO-like are action games where the player programs the movements of a character in some simulated world. The missions are to reach positions in the world, or to collect some objects. The movements are programmed through a simplified programming language. In most games in this type, the programs are created by drag and drop commands from a toolbar. This eliminates syntax errors. In adventure games, the player commands a hero to explore a world, to collect objects and to interact with other characters controlled by the game. The remainder games found belong to several types, such as simulations, real time strategies and maze games, and the authors called this group as general puzzles.

The LOGO-Like type seems more promising to us, as they use a practical approach asking the user to solve small and evolving missions repeatedly. The new skills are acquired when they are required and practiced many times during the game play (Kapp 2012). In programming learning, students acquire skills through practice and feedback (Prince & Hoyt 2002; Perkins & Martin 1986). The player has a little set of goals in each mission and tries to accomplish them in few minutes. Therefore, he/she practices several times the same concepts and may receive a new challenge in each new mission. The feedback is intrinsic in this type of game through the mission success or failure. When the player does not achieve the mission, the game gives the feedback informing what was wrong, and may be some clues to win the mission.

Usually the missions and challenges are defined into the game and the player's answers are evaluated without the teacher presence. The players can play and self-learn without the teacher intervention. There is another approach on game adoption that is asking students to create games. Games are created using particular environments and authoring languages (for example, Alice[1], Kodu[2] and Scratch[3]), or using conventional programming languages (as Java in Greenfoot[4] and JKarel[5]). The current research follows the first approach.

3. Enjoyment evaluation of serious games

Players will not play the game if they do not enjoy it(Sweetser & Wyeth 2005). Game enjoyment increases the level of interest in the subject and knowledge dealt by the game (Iten & Petko 2014). According Connolly et al. (2012), the understanding of enjoyment in games is poorly developed. There are some works that evaluated the enjoyment influences in serious games (Cohen 2014; Brom et al. 2015) and others propose instruments to measure it (Sweetser & Wyeth 2005; Fang et al. 2010; Fu et al. 2009). However, we did not find any research that evaluates the enjoyment in serious games for programming learning.

EGameFlow (Fu et al. 2009)adapted the Game Flow (Sweetser & Wyeth 2005) instrument to assess learning games. It is a scale that measures games in eight dimensions based on the elements of the Csikszentmihalyi (1990) flow: concentration, goal clarity, feedback, challenge, autonomy, immersion, social interaction and knowledge improvement. EGameFlow contains 42 questions presented in Likert-type scales, with 1 and 7 respectively representing the lowest and highest degree. The final value rates the overall sense of enjoyment on a scale between 0 and 100.

4. No Bug's Snack Bar game

The game mechanics are inspired in time management games. They include tasks divided in sequential steps that the player must perform within a time limit (Wassila & Tahar 2012). The games' contexts are based in everyday environments, as a restaurant oar store. The player controls the employee and the game controls the customers that make orders. The progress of the game is based on attending as many requests as possible within the time limit. In each new mission, the customers make more complex requests, requiring new and different sequences of steps and combination of items (Trefry 2010). The combination of one or more elements to create a new item requires problem-solving skills (Kapp 2012).

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[1] http://www.alice.org
[2] http://www.kodugamelab.com
[3]https://scratch.mit.edu
[4] http://www.greenfoot.org
[5] http://www.cs.tufts.edu/comp/10F/JKarel.htm

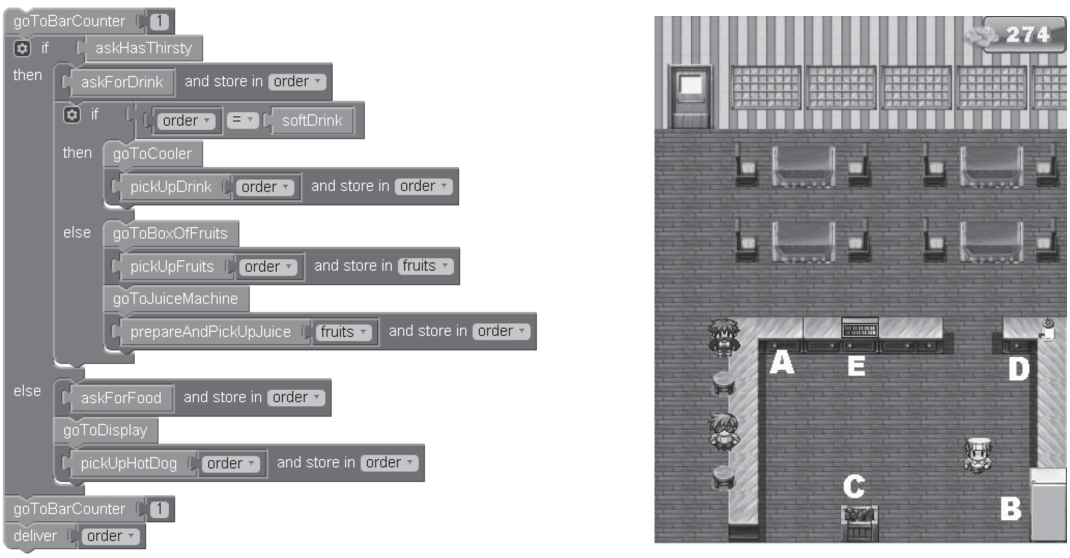
Essentially, in No Bug's Snack Bar the player controls an attendant of a snack bar. Customers require some combination of foods and drinks, and the attendant must go to places where they are prepared. The mission ends when the player meets all requests. Some missions are limited in time, in the amount of code or the quantity of variables. The code is produced by drag and drop blocks as in Scratch.

The initial game elements and rules that were defined are:

- The customers' possible requests: food (hotdog) and drinks (soft drink and juice). The actions the attendant has to do to fulfil the requests were also defined: go to some place, get ingredients and prepare what was requested;
- It should also be possible to include some constraints on the goals, as the amount of blocks and/or the quantity of variables used;
- The player gains points as he/she completes missions and earns bonuses based on the time taken to solve the mission;
- Explanatory text of the missions goals and the storytelling of the missions;
- A mission may start from scratch, from some predefined blocks or reusing code from a previous mission made by the player.

There is a set of commands to control the attendant and make him perform the tasks necessary to fulfil the customer request. Figure 1a shows a piece of one mission solution and Figure 1b shows the snack bar environment configuration for this mission.

The first block means that the attendant goes to the position 1 of the snack bar counter (represented by A in Figure 1b). The second block represents a conditional that verifies if the customer has thirsty. If it is true, then the attendant asks what the customer wants to drink and stores the order in variable *order*. The fourth block represents another conditional and compares the value of the variable order with the constant *soft Drink*. If they are equal, then the attendant goes to the fridge (B in Figure 1b) and takes the drink according to the order and stores it in the variable *order*. Otherwise, he goes to the fruit box (C in Figure 1b), picks the fruit according to the order and stores it in the variable *fruits*. Then he goes to the juice machine (D in Figure 1b), prepares the juice and stores it to the variable *order*. If the customer does not have thirsty, then starts another group of blocks to tend hunger. The attendant asks the customer and stores the order in variable *order*. He goes to the display (E in Figure 1b) and takes the hotdog according to the order and stores it in the variable *order*. After finishing the conditional block, the attendant returns to the customer and delivers the order. At this point, if the delivery matches the order, the player earns money, and maybe accomplishes some goals. Otherwise, the customer gets angry, the player receives a message error with the problem explanation, and the execution ends. Based on this feedback the student should fix his program and try again.



(a) (b)

Figure 1: a) Piece of one solution mission b) Snack bar environment configured for the mission

There are 16 missions covering the essential subjects, as variable manipulation, sequence of actions and conditionals. The game is divided in two phases: in the first phase the missions are related to variable manipulation and sequence of actions; in the second phase has the conditionals meaning the character ability to take decisions. The missions created until now are organized as follows:

- Missions 1 to 3, player learns the basics of dragging, running and debugging;
- Missions 4 to 6, player learns variable manipulation and sequence of actions;
- Mission 7, the same goals of mission 6, but constrained in blocks quantity;
- Mission 8, more complexity in the sequence of actions;
- Missions 9 and 10, the player receives bonus if he solves them into a time range, and constrained in the quantity of variables;
- Missions 11 to 16, use of conditionals, starting with simple conditional, followed by the else alternative, and finishing with nested conditionals.

Figure 2 illustrates the game environment: the animation and control area on the left, the code area in the middle, and the list of variables on the right. The player can run or debug his code. If he debugs, then the game shows the list of variables and runs one block at a time after each click of debug button.

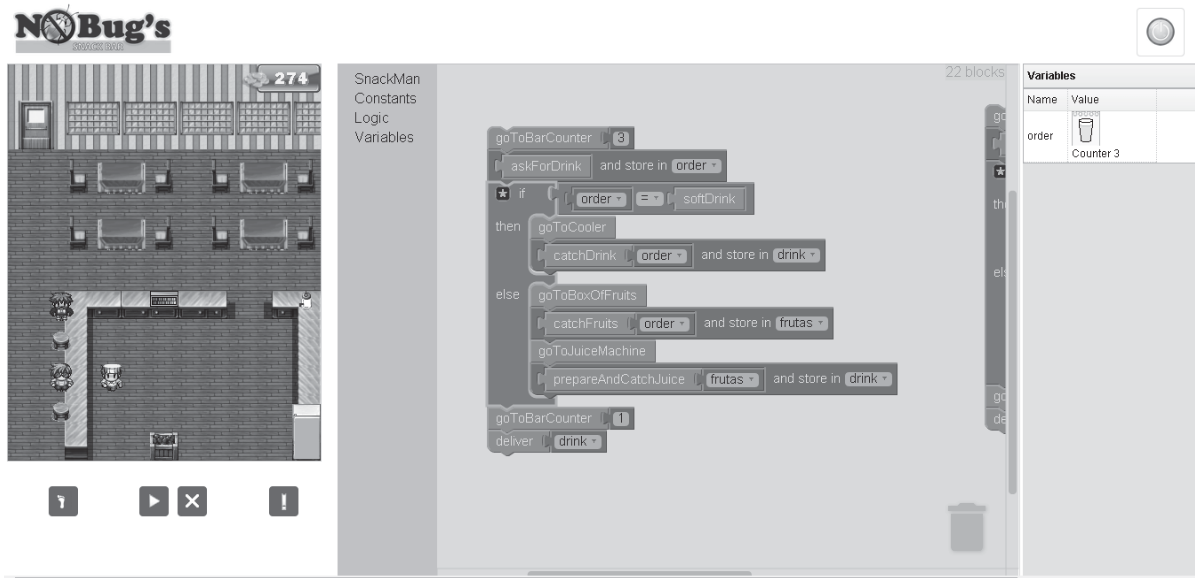


Figure 2: Game environment

5. Research purposes and questions

Even in serious games where learning is the main purpose, the game design must also take the enjoyment into consideration. This is important to promote student motivation, which is one of the reasons to use games in learning contexts. However, in the studies listed in Vahldick et al. (2014) the fun measurement is not present.

The purpose of this study, therefore, is to collect playing data and enjoyment opinion of the learners playing No Bug's Snack Bar and determine its strengths and weak points. Based on the results game improvements might be suggested.

The research questions examined in this study are as follows:

- What are the game features that need to be refined to improve enjoyment?
- How the difficulty level of each mission contributes to the flow state?

6. Methods

6.1 Participants

This study was conducted in March 2015 in a class of two distinct courses: Education Sciences (ES) at a national Portuguese university and Software Engineering (SE) at a state university in southern Brazil. Postgraduate students composed the ES group. The SE students were in the second week of the first semester. As the game aims to support initial programming learning we choose groups with no or very little programming experience. Also we selected two very distinct populations to get broader perspective about the game and eventual improvements that could be made.

6.2 Procedure

Both experiments were conducted in a computer classroom where each student was provided with a computer. The experiments had the same structure: first, the students answered an online demographic and game habits survey with nine questions. Next, they freely played for an hour. Finally, they answered the EGameFlow survey. We adapted EGameFlow to fit our game: items related to the social interaction and knowledge improvement dimensions were not considered, as no social and multiplayer aspects are involved in the game, and no knowledge measure was necessary at this point. The questionnaire had 29 questions presented in Likert-type scales, with 1 and 5 respectively representing the lower and highest degree. In this final questionnaire there were also two open questions: "What did you enjoy in the game?" and "What did you NOT enjoy in the game?"

This study disregarded the three first missions on the analysis because they present the basics of the game interface, and programming challenges start only in the fourth mission.

7. Results and discussion

Table 1 shows the demographics of the subjects. Nineteen students (n=19) played in ES class and sixteen (n=16) in SE class. The ES group includes essentially females with 23 years on average without previous programming experience. The SE students are younger male with some previous experience in programming.

Table 1: Demographics of the subjects

Variable	ES	SE	Total
Gender			
Male	1	15	16 (45.71%)
Female	18	1	19 (54.29%)
Age			
Mean (years)	23.26	18.19	20.94
SD	±3.42	±1.94	±3.80
What is your previous knowledge on algorithm or programming?			
Nothing	14	8	22 (62.86%)
Done some previous classes	5	6	11 (31.44%)
Done a course	-	1	1 (2.85%)
Work professionally	-	1	1 (2.85%)

We asked the students some information to identify their game habits (Table 2). Most of them play daily or weekly (62.86%) but prefer to play alone (65.72%) and not with others (multiplayer games). These are good characteristics of the sample in this experiment: first, they are students who like to play and second, they like to play alone. The first characteristic is important to avoid a bias in enjoyment evaluation, and the second is important because our game is not multiplayer. We were interested to identify if a group used to play significantly more than the other. We created an *hours spent per month coefficient* based in the answers of QH2 multiplied with a factor according the answers of QH3 (seldom-0, monthly-1, weekly-4, daily-30). Wilcox on test was utilized to determine if there is statistically significant evidence on the null hypothesis *H1: both groups play the same amount of time each month*. Wilcox on test has resulted in a $p=0.441 > \alpha=0.05$. Consequently, it is not possible to reject the null hypothesis.

Figure 3 shows the time spent (in minutes) by mission and Figure 4 shows the percentage of students that finished each mission. In this graph, as time evolve the number of students drops down. This does not mean the students abandoned the game, but we considered only the missions each student completed and not those they were working on when the experience time finished. The SE group accomplished the missions faster than the ES group, except in missions 6 and 11. The SE group made an average of 7.81 attempts per mission while this number for the ES group was 6.5. An interesting difference was noted in mission 7. While the SE group solved it 60% faster than mission 6 the ES group took 15% more time than in mission 6.The number of attempts in mission 7 was also very different: an average of 2.36 in SE group against5.94 in ES group. This comparison is interesting because the goal in mission 7 was the optimization of the program of mission 6, by cutting one command. We do not have enough data to perform an analysis on mission 11 because only 20% of students finished it.

Table 2: Game habits

Variable	ES	SE	Total
QH1. How long have you been playing computer games?			
Mean (years)	11.62	8.38	10.14
SD	±5.32	±3.24	±4.65
QH2. When you play computer games, how many hours on average do you play?			
Mean (hours)	1.49	18.19	20.94
SD	±0.93	±1.94	±3.80
QH3. How often do you play computer games?			
Daily	3	4	7 (20.00%)
Weekly	8	7	15 (42.86%)
Monthly	4	3	7 (20.00%)
Seldom	4	2	6 (17.14%)
QH4. How often do you play online with others?			
Essentially	3	3	6 (17.14%)
Half the time	3	3	6 (17.14%)
Little	5	6	11 (32.86%)
Seldom	7	4	11 (32.86%)

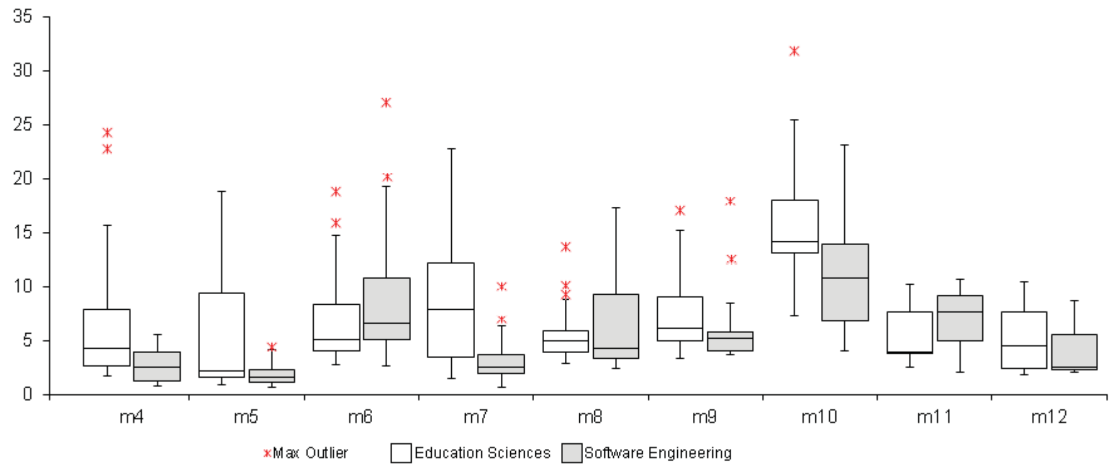


Figure 3: Time spent by mission

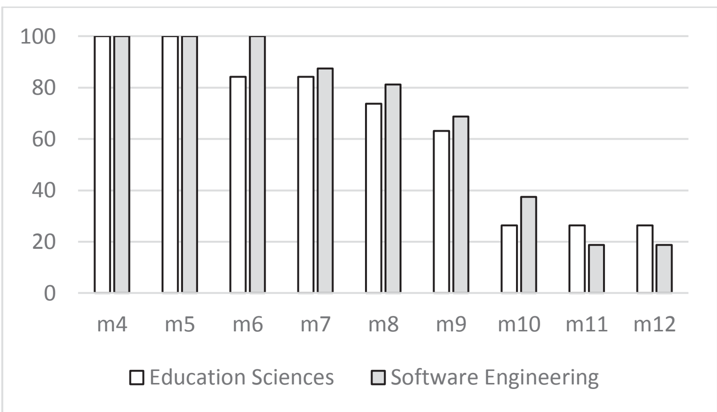


Figure 4: Percentage of students that finished each mission

Two independent samples t-test was conducted to compare the performance of the two groups: comparing time spent in each mission, and the quantity of finished missions. Differences in the time spent were found statistically significant (p=0.006; t=2.528) meaning that SE group was faster than ES group (as it could be expected considering their backgrounds). However, when comparing the number of finished missions between the groups, differences were not found statistically significant (p=0.379; t=-0.311), allowing us to retain the null hypothesis. Even if the SE group was fastest, the ES group was more persistent: on average more students concluded more missions than in the SE group.

Analysing the figure 3 as an interest curve (Schell 2008), based on the medians of each box, we can find some peaks and downs anticipating an expected rise in mission 10. This mission is the last of the first level, and it is longer and more complex than the previous ones. The new level starts in mission 11 where the curve starts again. Unfortunately, we could not test this level completely because it is necessary more than one hour to solve the 16 missions created until now. Observing the Figure 4, we can detect that all students in SE group solved mission 6 but some of them did not solve mission 7. Analysing the data, we found that two students did not finish mission 7, and in the mission 6 they spent the second and third worst times. All the students in ES group that finished mission 6 also finished mission 7.

The Cronbach's alpha of the EGameFlow Questionnaire in both groups is considered highly reliable (α_{ES}=0.916 and α_{SE}=0.946). In most dimensions the mean for the SE group were higher than for the ES group. The exception was the immersion dimension (Table 3). An independent samples t-test was conducted to compare the results in the questionnaire dimensions between the two groups. There were no statistically significant differences on the overall means (p-value=0.055; t=-1.643) to reject the hypothesis that both groups enjoyed the game at the same level. Transforming the overall means to a 100 scale, we have 76 for the ES group and 82 for the SE group. This suggests that the game pleased most players in both groups.

Table 3: EGameFlow scale

Group	Concentra-tion	Goal clarity	Feedback	Challenge	Autonomy	Immersion	Total
ES	3.8 (±0.50)	4.0 (±0.46)	4.1 (±0.54)	3.9 (±0.70)	3.4 (±0.95)	3.8 (±0.77)	3.8 (±0.59)
SE	4.1 (±0.46)	4.4 (±0.58)	4.3 (±0.57)	4.3 (±0.61)	4.2 (±0.63)	3.6 (±0.56)	4.1(±0.48)

The lower results were found in the autonomy dimension (ES group) and immersion(SE group).Autonomy is related to sense of control over their own actions and choices (Sweetser & Wyeth 2005; Fu et al. 2009).The open questions in the survey helped us to understand these results. Some answers of the ES group in the "not like" section were:

> *"Sometimes I feel confused by what I had to do to because there were many things to do at the same time."*
>
> *"It took me a long time to pass the level because sometimes I did not understand the directions given."*
>
> *"When the solution is large it becomes difficult"*

ES students had to learn several topics, such as the concept of sequence and variable manipulation, during the experiment. This lead to some mistakes and some felt they had lost control. However, the game tries to do some error prevention and recovery via warning messages (Federoff 2002). This suggests that we should review the error messages adding examples, counter-examples and learning content.

Immersion refers the degree of involvement, engagement and engrossment of the players in a game (Brown & Cairns 2004).Although Squire (2005) mentioned that "students were more concerned with game design issues than the quality of graphics", there was one dislike answer in the ES group and three dislike answers in the SE group regarding the game graphical design. According toSweetser & Wyeth (2005) two game elements should be used to foster immersion: audio and narrative. At the moment, the game does not have sound. A possible improvement is the introduction of ambient noise and some spoken orders or hints. In addition, the goals and missions can be better integrated within the game story.

Regarding the other five dimensions, we also have some findings based on the answers to open questions. The concentration is maintained through the provision of stimuli that attract and keep the player's attention, respecting a reasonable workload, and reducing tasks and elements not related to the main activity.71.42% of the positive open questions answers are focused on concentration. Some keywords and phrases found in the answers were "logical algorithms and programming tasks as game", "fun", "rewards", "goals", "real life activity", "chronometer" and "learning”. There were three negative responses from the ES group. Two of them complained about missions that required a higher amount of code and one student said that he/she could not concentrate in class to solve these types of problems. The only negative answer from the SE group in relation to the concentration refers to lack of stimuli in the game. The student answered that the game is too simple.

The analysis of interest curve in the Figure 3 can be reused to evaluate the challenge element. Previously we concluded that the curve of interest satisfies the Schell (2008)’s guidelines. However, the average time in mission 10 is about double of mission 9. We will need to reassess the challenges of mission 10 to reduce its average time. There were two answers related with "difficulty level" in the open questions: a positive in SE group and a negative from the ES group.

Goal Clarity and Feedback were the dimensions better evaluated in both groups. There were no answers related of goal clarity. We could find several answers to the open questions related to feedback. From the ES group we found four positive and five negative answers. From the SE group we identified three negative answers. Possibly these students associated some failure with the texts explaining the error in the program. Anyway, we need to improve the support when the student fails some objective.

8. Limitations

Our analysis and experiments are subject to some further limitations. The experiments were conducted within a lesson and all the students played the same quantity of time. However, as we could observe, the students did not play the same quantity of missions. People have different time to achieve pleasure. Perhaps we best measured the enjoyment if we could get it at second time from everybody after the final mission. We also could compare both measures and evaluated the changes in enjoyment through the time. Nevertheless, that requires more than one lesson or to request the students play out of the lessons. The first option is not possible because it disrupts the teacher’s work and the second option should integrate the class grade. In continuation of this research, we are planning use this game over a class then it will allow us use the proposed class grade integration. We also classified the players according the Bartle types (Bartle 1996): socializer, explorer, achiever and killer. We applied the Bartle coefficient (Andreasen & Downey 2015) to identify and sort the three most evident behaviour on each player. The intention was to correlate EGameFlow measure with the Bartle coefficient, and determine the correlation between dimensions’ pleasure and each type of player. These could provide us a fine classification of dimensions that need improvements. However, grouping resulted in some groups under five subjects, constraining us to run correlation statistical tests.

9. Final considerations

The purpose of this study was to investigate the enjoyment reaction to a serious game for programming learning. The goal was to determine if the students like to play it, and which improvements could be made. We involved two groups of distinct student types. The overall mean of EGameFlow scale (0-100) resulted in 76 for ES group and 82 for SE group representing that most players liked the game. Below we try to answer the research questions stated in section 5:

- What are the game features that need to be refined to improve enjoyment?

ES students expressed the need of improvements related to the autonomy dimension. SE students were more concerned with aspects related to immersion. The game should provide better scaffolds when the player does not progress after a number of attempts. We should also review the explanatory texts that appear in error situations. To increase immersion we need to improve the storytelling. The game should integrate the goals, feedback, failures explanation and rewards with the narrative. Audio should be introduced in the game and the graphics should be improved.

- How the difficulty level of each mission contributes to the flow state?

The interest curve pattern follows what Schell (2008) suggests: starts with some level of interest, and there are some peaks and downs, and finishes with a rising in the last mission of the level. However, the median time spent in the 10th mission is the double of the previous missions. Maybe we should reassess this mission trying to reduce the amount of challenges. For future work, we plan to allow the teacher to specify the missions, for example, the goals, the dynamics of customers, available commands and new machines and equipment to enhance the snack bar. This may facilitate the adoption of the game by a larger number of teachers. We are also adding new command blocks to suit the whole introductory programming course as iterative control structures, functions and arrays.

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Using Games to Raise Awareness. How to Co-Design Serious Mini-Games?

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Abstract: This study explores the usability of informant design as a framework to involve multiple stakeholders in designing serious games. First, it evaluates serious mini-games as a tool for social marketing campaigns. The study suggests that serious mini-games can provide an efficient alternative to more complex serious games, since mini-games are short games focused on a single concept or learning goal. Similar to more complex serious games, serious mini-games motivate and enhance players' interest in a particular topic but require only a small time-investment from players. Research suggests that the use of mini-games is even more promising if a set of different games is used to study a topic from different angles (Frazer, Argles and Wills, 2007). Furthermore, if each mini-game incorporates different gameplay mechanics, the games will appeal to more players. Thus, serious mini-games are the perfect tool for creating awareness of different aspects of a social topic in a fast, interactive and engaging manner. However, the question arises how to develop a platform for serious mini-games. Organizations responsible for developing awareness campaigns focused on societal issues must deal with many different stakeholders. Thus, in the development of serious mini-games each stakeholder should be heard. This study suggests the use of informant design as a framework for serious mini-games to increase the support of every stakeholder. Informant design provides an excellent design methodology for games since it offers great flexibility at whatever time and place co-design activities with each stakeholder occur. In the second part of the study, the phases of informant design and how they can be successfully applied in game design by creating our own set of serious mini-games to increase advertising literacy among adolescents are explored further.

Keywords: serious mini-games, co-design, learning game design, awareness, adolescents

1. Introduction

For several decades, the use of serious games as educational tools has increased. Researchers have shown that compared to more traditional media formats these games draw attention, enhance engagement in their topic and induce a positive attitude toward learning and behavioral change (Bourgonjon et al, 2010). However, many serious games are complex (simulation) games that require players learn a wide variety of often new and difficult skills. These games also require numerous hours to play and master effectively (Prensky, 2005; Trefry, 2010; Juul, 2012). Therefore, serious mini-games or casual games can provide a more efficient alternative, as they are short games that focus on a single concept or learning goal and require a small time-investment from players (Jonker, Wijers and van Galen, 2009; Illanas et al, 2011). Researchers have suggested that the use of mini-games is even more promising if a set of these games is are used to study a topic from different angles (Frazer, Argles and Wills, 2007). Thus, serious mini-games are the perfect tool for creating awareness of different aspects of a social topic in a fast, interactive and engaging manner.

However, the question of how to design a platform for serious mini-games arises. Organizations responsible for developing awareness campaigns focused on societal issues must deal with many different stakeholders who may have different (sometimes even conflicting) targets. Thus, in the development phase of serious mini-games these different stakeholders should be heard. The target group should be closely involved in the development process to ensure a good understanding of their needs and preferences. To increase the involvement of these stakeholders, this paper suggests the use of co-design in the development of serious mini-games. Although co-designing is widely applied in designing new technologies, to our knowledge, no study has examined how to successfully involve multiple stakeholders in the design process of serious mini-games. Thus, the aim of this study is twofold: It describes the promise of serious mini-games in the context of raising social awareness. The study presents a case study that used a methodological co-design framework for designing serious mini-games.

2. The educational value of casual games

Recently, a new wave of enormously popular casual video games that appeal to a broad audience has appeared, with more than 200 million players worldwide (Trefry, 2010; Juul, 2012). These casual games, or mini-games, are short games that are easy to learn and contrast starkly with traditional videogames (Smith and Sanchez, 2010; Illanas et al, 2011; Jonker, Wijers and van Galen, 2009; Trefry, 2010; Juul, 2012). Traditional videogames have become increasingly complex, and require several hours to master the rules and scenario conditions (Prensky, 2005, Trefry, 2010, Juul, 2012). Casual games consist of basic, often familiar, game mechanics and accessible content that make it easy for players to reach a high level of proficiency within a short period (Trefry, 2010). The rules of the game are simple and straightforward and remain unchanged throughout the game (Smith and Sanchez, 2010; Illanas et al, 2011; Trefry, 2010; Jonker, Wijers and van Galen, 2009). However, because the game mechanics are so easy to master, players can become addicted to surpassing their previous high scores and challenging other players.

The popularity of mini-games in combination with their flexibility and low development costs has inspired serious game developers to create educational mini-games. Educational mini-games, or conceptual mini-games as they are called by Illanas et al (2011), are casual games that focus on a single learning goal or concept (Illanas et al, 2011, Smith and Sanchez, 2010). Although more research is needed to prove the learning effects of these games, studies advocate the pedagogical and practical value these games can provide (Illanas et al, 2011; Smith and Sanchez, 2010; Jonker, Wijers and van Galen, 2009; Frazer, Argles and Wills, 2007). First, because mini-games consist of simple game mechanics and rules, no crucial learning time is wasted on learning how to play the game; instead, the player can immediately focus on the learning goal (Smith and Sanchez, 2010; Jonker, Wijers and van Galen, 2009). Although the game can become increasingly difficult at higher levels, the rules do not change, making it easy to evaluate students' educational progress (Illanas et al, 2011). Furthermore, learners tend to understand concepts better if they are presented with images. However, today this need is answered by the use of passive methods, such as movies. Games provide the opportunity to create an immersive environment in which players can interact with the images, which creates an even better learning opportunity than traditional media formats (Illanas et al, 2011). Furthermore, thanks to the games' short time span, they easily fit within a class period and can be played repeatedly during that period. Thus, students can practice and master the learning goal (Illanas et al, 2011; Prensky, 2008; Smith and Sanchez, 2010).

The educational value of mini-games and their ability to attract a wide audience of hardcore and trivial gamers make mini-games promising tools for public awareness campaigns, since the aim of such a campaign is to educate members of a community about a social problem (Sayers, 2006). Furthermore, the most effective awareness-raising messages are "short, simple, flexible and memorable," which describes the format of mini-games (Sayers, 2006). Some authors believe that mini-games are too trivial to provide any real educational value (Prensky, 2005; Frazer, Argles and Wills, 2007). Frazer, Argles and Wills (2007) offer a solution to this view in "uniting a number of different mini-games, incorporating different gameplay mechanics which focus on a single learning topic, into a single compendium." In other words, a learning unit or social issue can be translated into a mini-game platform by selecting concrete learning goals and then designing a mini-game focused on each goal. Thus, each mini-game represents a didactic unit that explore a broader learning area from different angles (Illanas et al, 2011). Although mini-games can stand alone as an educational experience, their pedagogical abilities can also be enhanced by embedding them as part of a blended learning approach in which educational mini-games are added to a pedagogical package consisting of lectures and in-class discussions (Smith and Sanchez, 2010; Frazer, Argles and Wills, 2007).

3. The use of co-design in game design

When awareness campaigns are developed for a societal issue, different stakeholders who often have different, sometimes even conflicting, targets should be included. Furthermore, stakeholders add important benefits to the project, such as knowledge, skills, and understanding and create support for the campaign topic (Hage, Leroy and Petersen, 2010; Reed, 2008). However, in (serious) game design, the target groups and other stakeholders rarely participate in the early design phases (Zaman et al, 2012). Therefore, this study uses a co-design method as a design framework to involve different stakeholders in designing serious mini-games. Co-design refers to the act of designing together and the use of collective creativity throughout the design process (Sanders and Stappers, 2008). When stakeholders and especially adolescents are included in the design process, two important co-design methods should be considered: cooperative inquiry and informant design. In cooperative inquiry, every stakeholder is included on a central design team on which every member is a designer with equal participation rights and every decision is made together. Because adults and adolescents are equal on this team, a new power structure must be negotiated in which both parties learn to work together, which often takes several months (Druin, 2002; Williamson, 2003). Informant design, however, advocates the involvement of stakeholders in the design process in a manner that maximizes the value of their contributions (Scaife et al, 1997). Different stakeholders, such as educators and end-users, provide specialized inputs that can shape the design at different stages depending on their stakeholders' knowledge and expertise. The project manager determines which stakeholders are included in each co-design activity. Due to the time-investment and the intensive cooperation demanded from stakeholders in cooperative inquiry, the design teams are often very limited in size, thus excluding a large group of stakeholders and lowering the level of representation for the results of the sessions (Williamson, 2003; Moraveji et al, 2007). Furthermore, time and longevity are vital to the success of cooperative inquiry, since every stakeholder in the design team first must learn to cooperate as an equal design partner and every decision must be joint (Guha, Druin and Fails; 2013, Druin, 2002). This is especially challenging when otherwise independent organizations with their own underlying goals (such as profit and non-profit organizations) need to cooperate. Informant design is thus a more realistic and practical option since it demands less time-investment from stakeholders and involves a larger section of the target audience resulting in great flexibility in the time, place and number of participants in co-design activities. However, to our knowledge, informant design has not been used as a design method for serious game design. In a methodological framework, Scaife et al (1997) define four phases of design: 1) defining the problem, 2) identifying the product requirements, 3) developing and testing low-tech prototypes and 4) testing high-tech prototypes. In each phase, different stakeholders are included depending on their expertise. In this model, the only brainstorming session with end-users occurs in the prototyping stage after the early design sessions. However, All et al (2013) showed the added value of co-design and brainstorming sessions before developing a prototype since this enables the integration of original ideas and game characteristics from the brainstorming into the early design phases, thus ensuring that the stakeholders' views, needs and preferences are integrated from the beginning. Therefore, we added a brainstorming session in phase 2 to the model. More detail on each phase is provided in the following case study.

4. Case study: Informant design of a platform of educational mini-games

Adolescents have become an important target group for advertisers. They are considered fully-fledged consumers who not only have their own money to spend but can also influence the purchase behavior of parents and peers (Cauberghe et al, 2012). Advertisements can help adolescents make informed choices, if they process the ads consciously and critically. To do so, adolescents must recognize and understand different advertising techniques and have a critical attitude toward advertising. However, due to the integration of advertising content in popular media content, the high level of interactivity and new commercial goals (such as data collection), recognizing these advertising messages as such and understanding their commercial intent is difficult. For inexperienced consumers, such as adolescents, this is almost unfeasible. Because adolescents are not aware of advertising strategies, they are not actively looking for information about these strategies. Thus, there is a growing need for awareness campaigns and educational tools for these new advertising formats (Cauberghe et al, 2012). Games and especially serious mini-games are ideal tools for promoting awareness of a social topic in an approachable manner because they are highly interactive and engaging activities that can be played by a broad public. Furthermore, the mini-game platform can be designed in such a manner that each game focuses on one learning goal of the campaign such as ad recognition and attitudinal advertising literacy, thus exploring advertising literacy from different angles. When developing such a campaign, it is important to involve different stakeholders, such as marketers and educational experts, since each stakeholder has his or her own views and policies on the subject which need to be taken into account to work toward the common goal of making adolescents critical consumers. Following Scaife et al's (1997) view, we considered the stakeholders in our project to be specialized informants; each stakeholder was selected based on his or her knowledge, skills and expertise. An overview of the stakeholders included in our project is in Table 1.

4.1 Phase 1: Definition domain

The first phase focuses on specifying the appropriate learning goals and identifying the problem areas of the learning domain (Scaife et al, 1997). For this phase, we used insights gained in a large-scale study the authors conducted earlier to explore adolescents' level of advertising literacy and the issues that arise in this context (Cauberghe et al, 2012). Advertising literacy is a three-dimensional conceptualization consisting of

- Conceptual advertising literacy, i.e. the conceptual knowledge of advertising e.g. ad recognition;
- Advertising literacy performance, i.e. the use of conceptual advertising literacy while processing advertising;
- Attitudinal advertising literacy, i.e. a person's general critical attitude toward advertising. (Rozendaal, 2011)

Table 1: Stakeholder overview

Stakeholder group	Organization	Name	Function
Industry expert	Duval Guillaume	Karel Vinck	Managing Partner
Industry expert	BBDO	Jan Algoed	Head of Digital
Industry expert	Mortierbrigade	Vincent D'Halluin	Strategic Director
Academic expert	University of Antwerp	Patrick De Pelsmacker	Marketing professor
Academic expert	Ghent University	Katarina Panic	Postdoctoral researcher on advertising literacy
Pedagogical expert	Ghent University	Tammy Schellens	Educational professor
Pedagogical Expert	DvM Secondary school	Stijn De Moor	Teacher (economy)
Pedagogical Expert	MS Denderleeuw Secondary school	Liesbeth Hoffelinck	Teacher (religion and ethics)
Pedagogical Expert	KTA Liedekerke Secondary School	Eva De Windt	Teacher (religion and ethics)
End users	DvM MS Denderleeuw KTA Liedekerke	109 youngsters between the age of 12 and 18	Students
Game developers (Development team)	Bazookas	Stefan Colins Christophe De Cock	Game developers

To understand and evaluate adolescents' advertising literacy levels, Cauberghe et al (2012) used qualitative and quantitative research methods: 11 marketers and 2 youth experts were interviewed, and 503 adolescents between the age of 12 and 21 completed a survey. Results show that the adolescents' conceptual advertising literacy levels of classic advertising formats range from moderate to high. However, the adolescents' conceptual advertising literacy was much lower for integrated and interactive advertising formats. Furthermore, even when adolescents recognize new forms, such as advergames and social media marketing, they do not process the forms critically. This makes adolescents an extremely vulnerable target group since the advertising sector regards them as fully-fledged consumers who have their own money to spend. Cauberghe et al (2012) have made several recommendations for government and educational interventions to counteract this vulnerability. The authors defined awareness campaigns as the primary tool for reaching adolescents between the ages of 12 and 16. These campaigns should focus on enhancing adolescents' critical thinking skills, especially toward new advertising formats. Thus, the goal of the compendium of mini-games is to provide a safe environment for adolescents that lets them practice online ad recognition, experience the influence exerted by advertisements and stimulate their critical thinking skills regarding advertising.

4.2 Phase 2: Brainstorming and definition requirements

To further determine the game requirements, brainstorming sessions were organized with the development team and industry experts (N = 3), pedagogical experts (N = 5) and adolescents (N = 109). Two topics were discussed in the sessions with the industry and pedagogical experts: 1) issues concerning advertising literacy in a new advertising context and 2) design of a serious advertising literacy game. The brainstorming sessions were recorded, coded and analyzed by the researchers. The industry experts' most important concern was that the games would be too pedantic, thus reducing the entertainment and immersive effect of the games. Thus, the games should induce stop and think reflection when the players are confronted with advertising, making adolescents realize how easily they can be influenced. One expert came up with the idea of a 'Where is Wally' game applied to online advertising. This would teach adolescents an automatic reflex that detects advertising when they are surfing the Internet. The pedagogical experts, who focused on the didactical side of the games, indicated that the games could function as motivational tools to start a topic debate in class, thus applying Frazer, Argles and Wills' (2007) blended learning approach. Therefore, the experts found it important that the games were short, could be played independently and focused on different aspects of advertising. These insights were used when the low-tech prototypes of the games and the game platform were developed.

Brainstorming sessions with 109 adolescents between the ages of 12 and 18 took place in six classes at four schools and lasted about 50 minutes. After a short introduction to the new advertising formats, the students were asked to sit in small groups of four to five persons and write down their favorite game elements (which genres, themes, music, characters they preferred) on Post-its. Afterward, each group received A3 sketching paper, game visuals, scissors and markers and were asked to create a storyboard for a game that aims to improve adolescents' online advertising literacy performance. An example game scenario was provided from an entertainment board game. The results were coded and analyzed using All et al's (2013) procedure. The storyboards (see Figures 1 and 2) were very helpful in identifying popular worlds, characters and game genres. We concluded that adolescents favor human characters, shooting assignments and city game worlds.

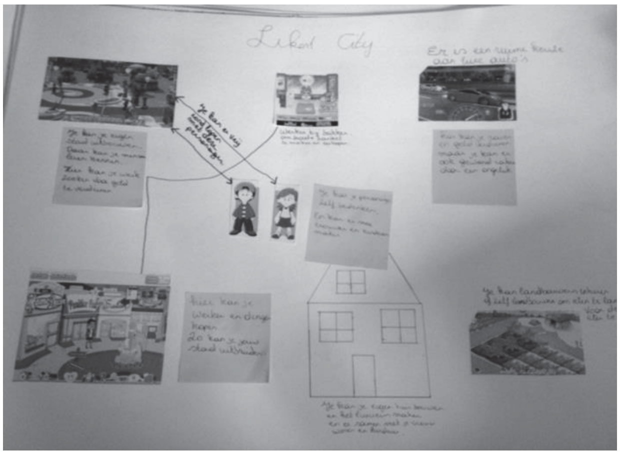

Figure 1: Scenario created in the participants' brainstorming session

Figure 2: Example of a brainstorming session

4.3 Phase 3: Design game scenario and testing

In phase 3, the development team had several brainstorming sessions with academic experts in which the results from the brainstorming sessions with the other stakeholders were incorporated to create the game world and determine the storylines and the game mechanics. These brainstorming sessions resulted in five game concepts. Four focused on improving conceptual and attitudinal advertising literacy and advertising literacy performance, and the fifth was designed as a quiz in which players can discover how critical they are of advertising and how much they actually know about new advertising formats. Each stakeholder was then asked to review the game concepts. After the project manager presented the game scenarios, the experts were interviewed, and the adolescents received a questionnaire on topics such as character style, color use, scoring system, storyline and competition. Similar to the input from the brainstorming sessions, the experts focused on the content of the games whereas the students also elaborated on game mechanics. Based on their feedback, the development team decided to omit one game that received negative feedback from the industry stakeholders and the adolescents.

4.4 Phase 4: Development alpha version and testing

The feedback from phase 3 was processed by the development team and translated into the final game design document. This document was the foundation for the development of the alpha versions of the games. At this point, only small changes can be made to the games, and if necessary, some new features can be added. The primary function of this phase is to test the usability of the games (i.e. game mechanics and perceived complexity). Therefore, the testing included only the target audience. Eight adolescents between the ages of 12 and 16 played the games individually and provided feedback with the think aloud method. Based on the feedback, some game features such as the scoring system and the controls were adjusted. Members of the development team also studied the adolescents' reactions while they were playing and noted any difficulties that occurred. These remarks were processed by the development team in combination with their own content review and bug testing. This fourth phase led to the development of the final version of the mini-game set.

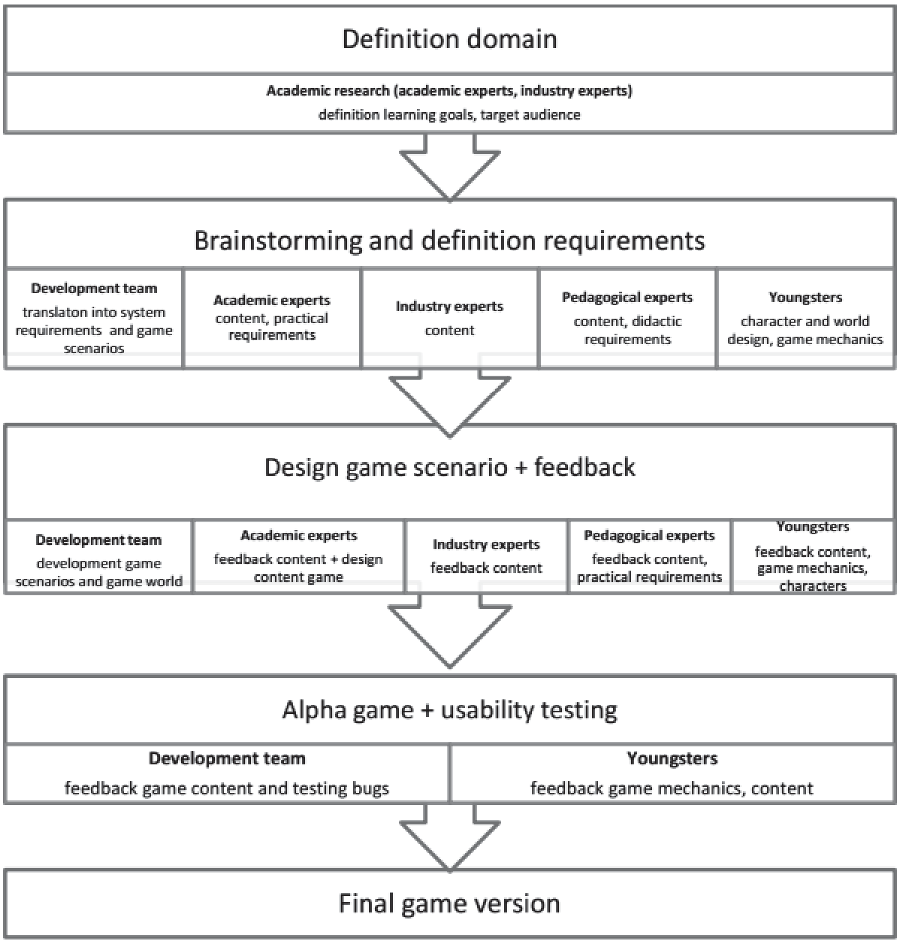

Figure 3: Methodological framework used in the study

5. Conclusion

This study has shown that a serious mini-game platform can be a promising tool to raise awareness of a societal issue. This platform can focus on different aspects of the societal issue in an entertaining way, thus motivating players and inducing a positive attitude toward learning and behavioral change. Moreover, serious mini-games provide a more time-efficient and budget-friendly alternative to more complex serious games. Whereas complex serious games take multiple hours to master, mini-games can be played within a few minutes; thus, players will easily be motivated to play these games repeatedly exposing them several times to the games' learning goals. Furthermore, thanks to their simplicity and ease of use, they can be played by hard-core gamers as well as casual gamers of all ages and thus are an efficient tool for reaching a broad public. However, designing a set of mini-games can be challenging since various stakeholders must be consulted and included. Therefore, this study applied informant design as a framework that involved different stakeholders as specialized inputs in the game's design process. In each phase, the added value of the different stakeholders was identified: Whereas the industry, pedagogy and academic experts focused on the game content, didactic and practical requirements, end-users provided interesting input on game mechanics and world design. Although each stakeholder's input was coherent in every phase, the role of the stakeholders differed each time. First, in the domain definition phase, the stakeholders acted as informants, expressing their views on the social topic. In the brainstorming phase, the stakeholders were informants and designers who again provided their views on the topic but also designed possible game scenarios. This phase was crucial to determine the requirements and game elements that should be used in the design phase to answer the needs and preferences of every stakeholder. Finally, in the feedback and testing phase, the stakeholders became testers who provided feedback on the scenarios and suggested possible adjustments. Although stakeholders are generally involved only in this last testing stage of the game design process, this study showed that stakeholders can provide the development team with useful insights into the content that corresponds with the experts' view on the topic and the game elements that will appeal to the target audience. However, when stakeholders are involved only in the final testing phase, only small adjustments can be made to the game; thus, a lot of input will be neglected. Although this project focused on the development of a set of mini-games that aims to raise awareness of a societal issue, we believe that the informant game design framework can be used for any serious game project in which input from different stakeholders is needed. The central idea of this framework is that each stakeholder is invited to join the project when his or her expertise is most needed. As a result, stakeholders take up different roles in one project. To make sure this project is successful, certain guidelines must be respected. First, the central topic of the game must be clearly defined. In this phase, different stakeholders, of whom the end-users are always one, should be identified to participate as informants who share their knowledge on the subject. Second, a clear learning goal should be determined, preferably as a short mission statement so that all members of the development team clearly understand the goal of the serious game. Third, stakeholders' input should always be gathered before design sessions so the development team knows which content and game mechanics should definitely be included in the game scenario.

6. Limitations and further research

First, due to the strict timing of the project and the schedules of different stakeholders, the experts were interviewed separately. Possibly more input could be gathered from larger brainstorming sessions in which a focus group of experts is consulted. Another possibility is to organize one general brainstorming session in which different focus groups consisting of industry experts, pedagogic experts, the target audience and one group consisting of a representative of each stakeholder group participate. In this session, every group can first brainstorm about a possible game design and via a transfer system each group could provide feedback on the concepts of the other groups, thus possibly resulting in a more defined game concept. Further research could explore different brainstorming scenarios. Another limitation is the questionnaire used in the third phase to structure the adolescents' feedback. Although several open questions were included, the questionnaire likely directed the adolescents' answers. More insights could be gained by performing several in-depth interviews. Finally, there is the issue that the brainstorming session as the feedback session with the adolescents was executed in a school environment within the restricted time period of the lesson. This could have restricted the creative input from the adolescents. When working with volunteers, the project manager should make sure that there is a good mix of frequent gamers and casual gamers to provide input for the project.

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Wait and see? Studying the Teacher's Role During In-Class Educational Gaming

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Abstract: The increasing use of social network sites (SNSs) entails several privacy risks. Therefore, a multitude of educational interventions have been developed to raise risk awareness amongst teenagers and to change unsafe behavior. However, most of these interventions are developed from a formal educational perspective. We hypothesized that traditional courses to teach about risks on SNSs are less effective to increase awareness and to change unsafe behavior, as they are further away from real life SNSs, which are mostly used as entertainment during leisure time. Moreover, an important added value of teacher involvement during educational game play in class was hypothesized. A quasi-experimental study was set up in 11 secondary classes, involving 80 pupils divided over 4 conditions. In these conditions, 4 different interventions were compared, in which pupils: (1) played a serious game on a tablet computer without teacher involvement, (2) played a serious game on a tablet computer while the teacher summarized the learned content every five minutes, (3) received a traditional course on privacy risks and (4) received a course on a different topic (control condition). In a pretest-posttest survey, we measured risk awareness, pupils' attitudes towards risky behavior, and their behavior. Moreover, qualitative data from open questions in the survey established whether pupils were aware of the topic of the game and the course, and what they had actually learned. The results revealed that all interventions caused an increase in awareness compared to the control conditions. Moreover, a better attitude towards safe behavior was found, but this increase was equal over conditions. No impact could be found on pupils' behavior. Finally, qualitative results showed that pupils in the condition with teacher involvement were more aware of the topic of the game than those who played the game without teacher involvement. This research clearly shows that more efforts should be put in the evaluation of educational games in a real-life classroom setting, not only to find out whether these games are effective, but also to find out how they should be implemented and what the role of the teacher should be.

Keywords: online safety, secondary education, teacher, privacy, game-based learning, evaluation

1. Introduction

In the current cyber society, new participatory platforms for communication are rapidly evolving. Social network sites (SNSs), also called online social networks, are an expression of these new communication technologies. Basically, SNSs are Internet communities that allow individuals to interact online through profiles representing their identities and their networks of connections (Acquisti and Gross, 2006).

Although many authors emphasize the numerous opportunities which SNSs offer, there are also many documented risks accompanying the use of SNSs (Christofides et al., 2012). Teenagers often post a lot of personal and sometimes risky information on the profile of their SNS (Livingstone et al., 2011; Vanderhoven et al., 2014b). This particularly challenges their privacy when they do not use the privacy settings of their SNS in a way to protect their information from strangers. Survey research has shown that 29% of teens sustain a public profile or do not know about their privacy settings and 28% opt for partially private settings such that friends-of-friends can see their page (Livingstone et al., 2011). Observational research shows that these numbers might even be an underestimation, as teenagers might not be aware of the amount information they (publicly) share (Vanderhoven et al., 2014b).

Given the possibly harmful consequences of over-sharing personal information online (Livingstone et al., 2011; Mcgivern and Noret, 2011), the role of school education to teach online safety has been emphasized by different stakeholders, including teenagers themselves, parents, teachers, policy makers and researchers (Livingstone and Haddon, 2009; Marwick et al., 2010; Safer Internet Programme, 2009; Tejedor and Pulido, 2012). School education needs to enable pupils to participate fully in public life (The New London Group, 1996), which implies in the 21st century that schools have a responsibility to teach teenagers how to behave safely on SNSs.

Therefore, the number of prevention campaigns and awareness raising interventions has expanded tremendously. However, a systematic review showed that only few of these interventions have been evaluated (Mishna et al., 2010). Still, recent evaluation studies of school programs on online safety are promising, as they show an increase in awareness and in rare cases even a decrease of unsafe behavior (Del Rey et al., 2012; Menesini et al., 2012; Vanderhoven et al., In press).

However, the focus of these interventions starts predominantly from a formal educational perspective. This results in formal and rather traditional courses on online safety (e.g., Vanderhoven et al., 2014a). These courses are in contrast with the regular use of SNSs, which is most often as entertainment during leisure time. Based on the educational principle of situated learning, which states that learning is more likely to be meaningful if it is embedded in a realistic context (Duffy and Cunningham, 1996; Snowman et al., 2008), we hypothesize that bringing the topic of safety on SNSs into the classroom in the form of a traditional course might result in a lack of motivation and might therefore decrease the impact. On the other hand, using media and technology to simulate the authentic context of using SNSs might increase the motivation and impact. Moreover, in contrast to the formal setting of a traditional classroom course, the authentic context of educational games may originate behavioral improvement, in addition to the foreseen knowledge increment. The challenges and problem solving elements of a game have been shown to transform the attitude of the learners not only within the game, but also in a transferred way outside the game in real-life settings (Prensky, 2005).

Educational materials for non-formal or informal contexts (Vadeboncoeur, 2006) do exist, but these interventions are not evaluated (Insafe, 2014) and therefore it is not sure whether they increase motivation or whether they have an impact on risk awareness or behavior. Consequently, the present study focuses on the evaluation of a game-based intervention.

1.1 Evaluation of educational games

In recent years, some critiques have been formulated with regard to the research design of evaluation studies of educational games. A major drawback seems to be the lack of a control group receiving another educational intervention, covering the same content. If no intervention is implemented in the control group, this might lead to an overestimation of the instructional effect (Hays, 2005). Moreover, according to some authors, a control group where a more traditional –viable and less expensive- activity is implemented, is necessary in order to justify the substantial financial investment that is required for the development of a game-based intervention (Clark, 2007). A second major drawback is the non-implementation of a pre-test, as differences between groups on for instance, risk awareness, might have existed before implementation of the intervention, making results potentially invalid (Chen and O'Neil, 2005).

In terms of implementation of the game-based interventions, a variety of implementation methods are used in existing studies. Games are either implemented as a stand-alone intervention or as part of a larger program (Backlund and Hendrix, 2013). When embedded in a larger program, elements of the program differ across studies as well (All et al., 2014), which can lead to confounding effects and therefore an overestimation of the effect of the DGBL intervention (Joy and Garcia, 2000). The larger part of these studies are typically conducted in a school context with the regular teachers, which again results in less control and confounding variables (Brom et al., 2012). Moreover, when a teacher implements the DGBL intervention, teacher influences can also occur. A study conducted by Brom et al. (2012) has for example shown that significant findings in one experimental group compared to its matched control group could not be found in another experimental group compared to its matched control group, due to teacher influences.

1.2 The role of the teacher

There are several reasons to expect that the role of the teacher during in-class gameplay is important to enhance learning. First of all, as Prensky (2001) highlights, today's students seem to have problems with reading, thinking, and reflection. He blames this on the twitch-speed world, where there is less and less time and opportunity for reflection. He claims that one of the challenges of teaching 'digital natives' is to include reflection and critical thinking in learning, for example through a process of instructor-led debriefing. Second, research about the implementation of technology in the classroom (i.e., tablets in education) shows that including classical moments with the teacher guiding class discussions about the subject is critical to obtain good learning results (Montrieux et al., 2014). When pupils had to work independently with their tablets, without classical moments guided by the teacher, they were also more frustrated and asked for more help. Similar results were found in research about the role of the teacher when integrating web-based learning environments in the classroom (Raes and Schellens, 2015). Finally, case studies show that the use of educational games is often intertwined with more traditional teaching, which produces better retention of the information learned by the pupil (Wastiau et al., 2009).

However, research about the role of the teacher during in-class gameplay is scarce, and therefore there is a lack of implementation guidelines for teachers willing to use games in their classroom. This is one of the main obstacles that make it difficult to integrate games in the classroom: as games are often not developed for implementation in class, they are not compatible with the curriculum and the structure of courses (Wastiau et al., 2009). This is particularly the case when it comes to cross-disciplinary subjects such as online privacy.

Hence, in the present study, we aim at taking the aspects described above into account. We set up a quasi-experimental study in an authentic classroom setting to evaluate a game-based intervention called MasterF.I.N.D.. To counter the critiques described above (Clark, 2007; Hays, 2005), two forms of control group were included in the study, which were compared to the game-based learning condition: one that received a traditional educational intervention (course), covering the same content and one that received a traditional educational intervention, covering different content. Moreover, we used a pretest-posttest design, to take into account existing differences between groups before the intervention. Finally, we aim at looking at the influence of the addition of extra elements to the intervention on its effectiveness. More specifically, we aim at studying to what extent the role of a teacher influences the effectiveness of the game.

1.3 MasterF.I.N.D.

Master F.I.N.D. is a non-evaluated educational game developed by Child Focus, a Belgian organization working on, among others, online safety for children (Child Focus, 2015). The game aims to raise awareness about privacy risks on SNSs, and to change unsafe behavior. The context of the game is a fake SNS. MasterF.I.N.D. was developed to be played by teenagers individually, but the developers claim that the game can also be played in class. However, there are no particular guidelines of how the game can be implemented in a classroom setting, nor on the role of the teacher during in-class gameplay.

In the present study, two interventions were created: one in which the game was played individually in-class, and one in which the game was alternated with classical teacher-led debriefings, based on the suggestions described in previous research literature (Montrieux et al., 2014; Prensky, 2001; Raes and Schellens, 2015),

2. Research questions

Based on the fact that existing informal interventions about online privacy risks, such as Master F.I.N.D. are not evaluated, and based on the fact that the role of the teacher is undefined in the case of Master F.I.N.D. as it is in many other educational games, a quasi-experimental study was set up to find an answer to the following research questions:

- Is there an increase in risk awareness and/or a decrease of risky behavior with teenagers who played Master F.I.N.D in class compared to teenagers who are involved in a regular course? (impact-evaluation)
- Is there an added value of involving the teacher (instructor-led debriefing) while pupils are playing Master F.I.N.D in-class?

3. Method

3.1 Participants and design

A quasi-experimental study was set up in 11 secondary classes, involving 80 pupils (M_{age}=13,8 years). Four short-term interventions (1 hour) were compared, in which pupils: (1) played MasterF.I.N.D. on a tablet computer without teacher involvement, (2) played MasterF.I.N.D. on a tablet computer while the teacher summarized the learned content every five minutes (teacher-led debriefing for every played mission), (3) received a traditional course on privacy risks and (4) received a course on a different topic and did not receive a course on privacy risks (control condition),.

3.2 Materials

3.2.1 MasterF.I.N.D.

Master F.I.N.D. is a serious game developed to learn about privacy risks on SNSs. In this game, the player is a webdetective that needs to solve several missions. Missions can be solved by searching for information on the profiles of several users of a fake SNS. Through the available information on the profiles, gamers are confronted with several privacy risks. For example, one of the missions is to find out where a certain person was on a certain moment in time. This information could be derived when searching on this person's profile, as there was a picture posted of this person in Paris. By searching and finding this information, gamers should learn that by sharing pictures, one gives away certain information about one's location. There are 20 missions in total, but in the current research, the first 8 missions needed to be played during a 1-hour course in class (to ensure comparability with the traditional course).

3.2.2 Traditional course on privacy risks

The traditional course on privacy risks was based on an evidence-based educational package, which has proven to be effective in raising risk awareness and changing risky behavior on SNSs (Vanderhoven et al., 2014). The content of this course was adapted so that it corresponded the content that was tackled in the game MasterF.I.N.D., having a main focus on privacy risks. The course was a 1-hour package that was based on several design guidelines, derived from prevention research (Nation et al., 2003), instructional theories (constructivism, Duffy and Cunningham, 1996), and a design-based research on specific design guidelines for interventions about risks on SNSs (Vanderhoven et al., 2015a). It started with an introduction on the topic of privacy risks on SNSs, followed by an exercise with a fake worst-case scenario SNS-profile, a class discussion, a voting card game with emphasis on individual reflection and finally a summary of all the important information that should have been learned during the course.

3.3 Procedure

Before starting with the intervention, we asked the teachers if they wanted to cooperate. To assure external validity, the regular teacher of the pupils was involved in the intervention in all conditions. In the first condition without teacher involvement, the regular teacher was only available in class for class management, in the second condition the teacher led a debriefing after every mission that was played, and in the third and fourth condition the teacher gave a traditional course. When the teachers consented to cooperate in the research, their students were given the link to an online survey. Approximately one week after they had filled out the first survey, they participated in the intervention. Classes were randomly divided over the four conditions. After this session, students were provided with the link to the second online survey. The complete research procedure is depicted in Figure 1.

3.4 Measures

A mixed-methods approach was used, collecting both quantitative and qualitative data from pupils in a pre- and post-test online survey, to overcome the weaknesses of single approaches (Denscombe, 2008).

3.4.1 Quantitative measures

The survey started with a few general questions concerning the pupils' gender and age. To measure the effectiveness of the intervention, a number of scales were developed based on previous research (Vanderhoven et al., 2015b). Firstly, to assess the pupils' awareness of privacy risks on SNSs, an index was developed consisting of six items on a 7-point Likert scale which measured the awareness of different privacy risks (e.g., "The personal information on my profile can reach more people than I intend", 1= low awareness, 7= high awareness). In addition, in order to value the pupils' attitudes towards safer behavior on SNSs a sumscore was calculated based on three subscales, consisting of three items each, which were validated in previous research (Vanderhoven et al., 2015b). These subscales measured the attitudes towards three different privacy behaviors (i.e., not posting too much personal information, using privacy settings and reflecting before posting information). An example item is "I belief that changing the privacy-settings of your social network site is a positive thing to do". Finally, to value the pupil's behavior, another sumscore was made based on three other subscales, each consisting of three items, based on the same behaviors (Vanderhoven et al., 2015b). An example item is "I think before I post something on my social network site profile". The resulting index-scores gave an indication of the general attitude towards safe behavior (1= bad attitude towards safe behavior, 7= good attitude towards safe behavior) and their actual behavior (1= unsafe behavior, 7= safe behavior).

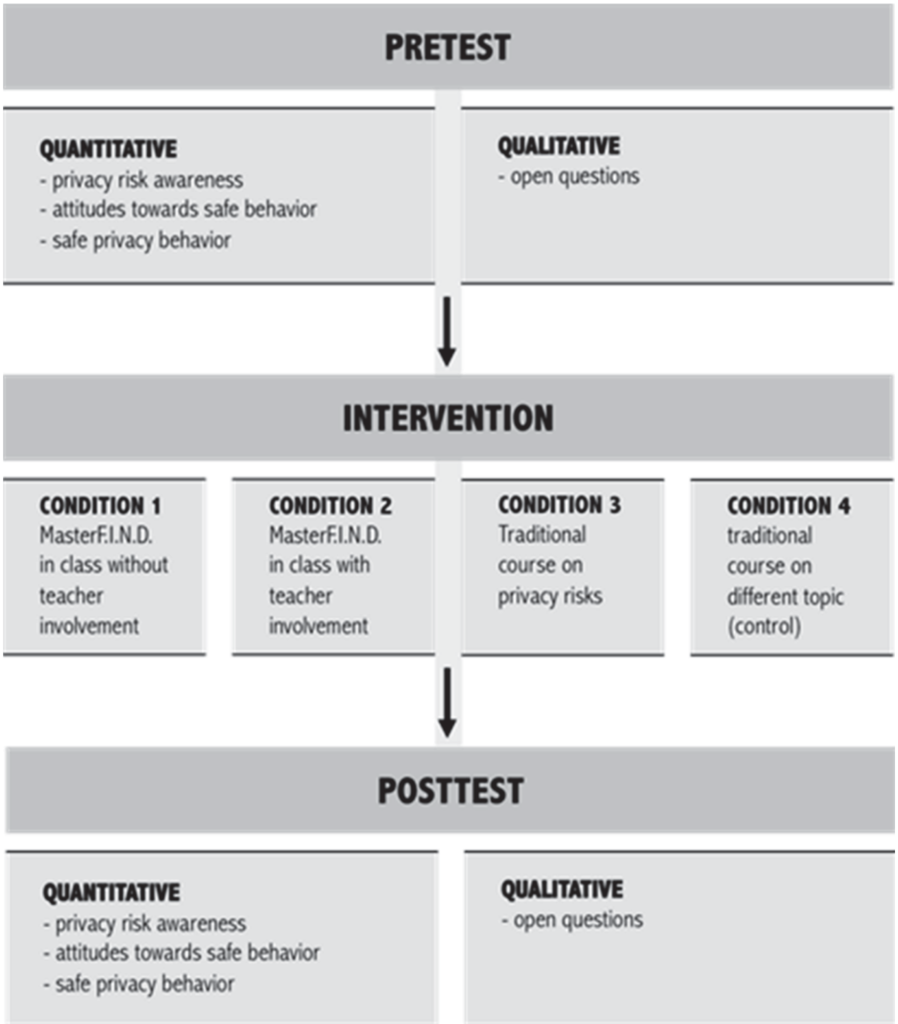

Figure 1: Procedure and design of the quasi-experimental research

3.4.2 Qualitative measures

An open question was added to the online survey, which measured whether pupils were aware of the topic of the game and the course ("What do you believe this game was about?")

3.5 Analyses

To find out whether the interventions had a differential impact on awareness, attitudes and behavior, three multivariate repeated measures were conducted with the time of measurement as a within-subject variable, condition as a between-subject variable, and the awareness-, attitude-, and behavior- scale respectively as dependent variables. Moreover, the open question about the topic of the game was coded: 1 if they knew that the game was about privacy risks on SNSs, 0 if they did not (e.g., if they only referred to missions and detectives).

4. Results

Preliminary analyses show that pupils' awareness about privacy risks increased in all three conditions with an intervention on this topic, compared to the control condition ($F(3,76)=4{,}18$, $p=.009$) as can be seen in Figure 2. While there is also a better attitude towards safe behavior ($F(1,76)=17{,}19$, $p<.001$), this increase is equal over conditions. No impact could be found on pupils' behavior ($F(1,76)=2.43$, $p=.12$).

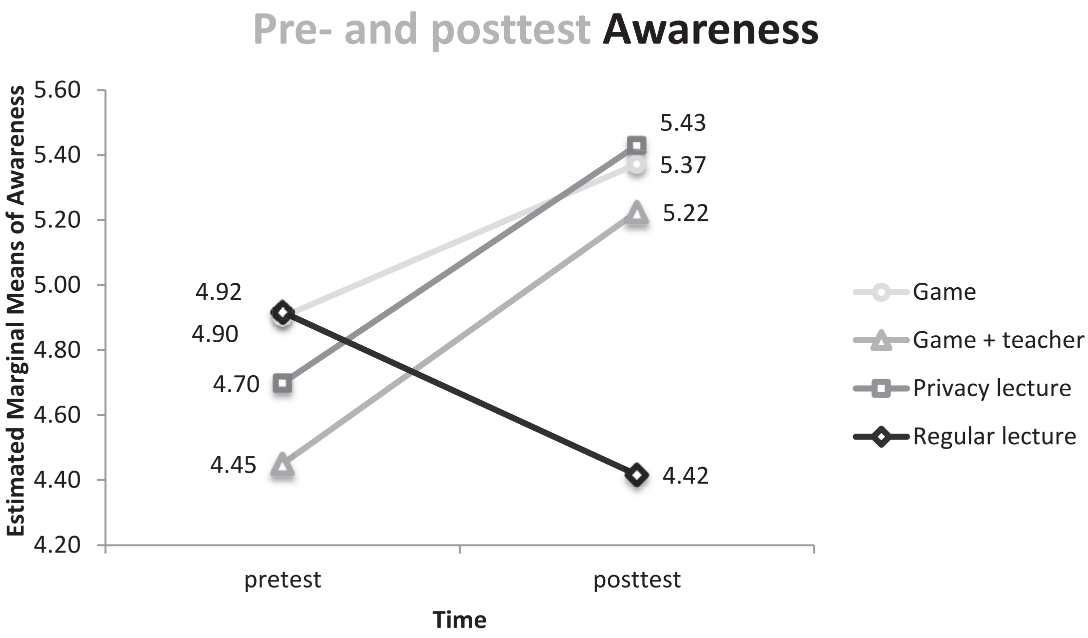

Figure 2: Difference between pre- and posttest awareness for the different conditions

Interestingly, when we analyzed the qualitative data, we found that pupils were more aware of the actual topic of the game or course when the teacher was involved, compared to the condition in which they had to play the game individually ($X^2(2)=9.78$, $p=.008$). While 78% of the pupils in the game-only condition mentioned typical aspects of the game when asked for the topic (e.g., "*we were detectives and we had to solve missions*"), 70% of the pupils in the teacher-led condition mentioned the underlying message and sometimes even transferred this knowledge to their own life (e.g., "*we had to find information about others, to show that you can easily find this information and that you should use your privacy settings*").

5. Discussion and conclusion

With regard to the first research question, we found that the game MasterF.I.N.D. had an impact on awareness, but not on behavior. This contradicts the goals that were put forth by the developer Child Focus. However, this lack of impact on behavior is not totally surprising. In previous evaluation studies of media literacy interventions and online safety interventions in particular, it has been shown that an impact on behavior is rarely found (Martens, 2010; Mishna et al., 2010; Vanderhoven et al., 2014a). Still, some interventions do have an impact on behavior (e.g., Vanderhoven et al., In press), and it is therefore interesting to focus future research on critical aspects of these effective interventions as a change in behavior is one of the main goals of e-safety interventions.

With regard to the second research question, we found that the role of the teacher has an important impact on the awareness of the pupils about the actual topic of the game. One might consider this conscious knowledge less important than the unconscious raise in awareness that was found. However, the developers of the game emphasized that this conscious knowledge was one of their goals, as they believe this knowledge is necessary to impact their attitudes and to transfer the learned knowledge to their own life. Although discussion about the importance of consciousness about learned information is possible, this research clearly shows the importance of studies that focus on the role and impact of the teacher during in-class gaming.

As a conclusion, it can be stated that more efforts should be put in the evaluation of educational games in a real-life classroom setting, not only to find out whether these games are effective, but also to find out how they should be implemented and what the role of the teacher should be.

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How to Evaluate Educational Games: Lessons Learned From the Evaluation Study of Master F.I.N.D.

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Abstract: Increasingly more researchers are emphasizing the importance of evaluating educational games in real life classroom settings, as most of these are developed without any theoretical consideration and without any evaluation afterwards. This causes uncertainty about the effectiveness of these games. Based on the reflections we made during a quasi-experimental evaluation study of MasterF.I.N.D., an educational game that aims to raise awareness about risks on social network sites, we want to put forth a few pitfalls that need to be taken into account when evaluating educational games. While we support the decision to evaluate such games using quasi-experimental designs in authentic classroom settings, we point towards the risks of evaluating games that were not developed based on theoretical considerations and practical requirements. We argue that including academic research only after development, might result in wasted effort and useless results. We illustrate this argument based on the case of the evaluation study of Master F.I.N.D., which was developed by industry without much theoretical consideration. Because of this lack of academic input during the development phase, we stumbled upon several problems that guided our research decisions and thereby jeopardized the validity of the research results. Based on this research example, we put forth some guidelines to take into account when starting an evaluation study. Furthermore, we propose another approach known in educational sciences as design-based research. This research approach involves the final users (i.e., pupils and teachers) during the full design process, and iteratively evaluates the impact of the game, resulting in both an evidence-based effective game and theoretical guidelines to develop such a game. We claim that this approach is necessary to establish both useful academic results and guidelines for practice.

Keywords: assessment, methodology, design-based research, theory, design, user involvement

1. Introduction

Several authors emphasize the possible positive impact of digital games for learning on the digital native generation (Connolly et al., 2012; Prensky, 2001). Since today's young people grew up with technology, and play on average 10 000 hours of video games, these games became their native language (Prensky, 2001). Therefore, these games also turned into possible tools to teach a variety of topics.

To know whether these games produce learning, assessment is necessary. Ever since the idea of learning by playing games became popular, a lot of evaluation studies have therefore been conducted, to find out whether they indeed have an impact on learning outcomes, that is both on cognitive outcomes and affective outcomes (Bellotti et al., 2013; Connolly et al., 2012). A systematic literature review of these evaluation studies, shows that playing computer games is related to a variety of perceptual, cognitive, behavioral, affective and motivational impacts and outcomes (Connolly et al., 2012).

This impact evaluation posits several pitfalls, especially since research and development are not always going hand in hand. Moreover, studies on the effectiveness of serious games and digital game based learning stumbled upon a series of methodological issues (All et al., 2014; Hays, 2005). We argue that awareness of these challenges brings research to a higher level. Therefore, this paper tries to point out certain pitfalls, based on the lessons learned during the evaluation study of an educational game called MasterF.I.N.D. In the following, we describe this research and its main goals, followed by the lessons we learned during the study. Finally, we propose an approach that might overcome the posed problems.

2. The Master F.I.N.D. evaluation study

Master F.I.N.D. is an educational game that aims to raise awareness about privacy risks on social network sites (SNSs), and to decrease unsafe behavior on these websites. SNSs are increasingly popular Internet communities that allow individuals to interact online through profiles representing their identities and their networks of connections (Acquisti and Gross, 2006). As the users of these SNSs are typically posting a lot of personal information on their profile, they face certain privacy risks (Livingstone et al., 2011). This raises concerns, resulting in several political decisions about the education of teenagers to teach them about these privacy risks. A variety of intervention programs have been developed and tested (e.g, Insafe, 2014), delivering promising results about the role of school education to teach teenagers about privacy risks on SNSs, and how to behave safe on these websites (Vanderhoven et al., 2015).

Child Focus, a Belgian organization with a focus on children's health and safety (Child Focus, 2015), developed several of these interventions, including the educational game called Master F.I.N.D. The context of the game is a fake SNS. Using media & technology to simulate the authentic context of using SNS, Master F.I.N.D. aims to increase the motivation and impact, as is predicted by theories of constructivism and situated learning (Duffy and Cunningham, 1996; Snowman et al., 2008). In this game, the player is a web detective that needs to solve several missions. Missions can be solved by searching for information on the profiles of several users of a fake SNS. By searching and finding this information, gamers are confronted with several privacy risks. For example, one of the missions is to find out where a certain person was on a certain moment in time. This information could be derived when searching on this person's profile, as there was a picture posted of this person in Paris. By searching and finding this information, gamers should learn that by sharing pictures, one gives away certain information about one's location. There are 20 missions in total.

To verify whether MasterF.I.N.D. obtained it's goal to raise awareness about privacy risks on SNS and to change unsafe behavior, we set up a quasi-experimental study involving 80 pupils (M_{age}=13,8 years)., comparing 4 conditions, in which pupils: (1) played MasterF.I.N.D. on a tablet computer without teacher involvement, (2) played MasterF.I.N.D. on a tablet computer while the teacher summarized the learned content every five minutes (teacher-led debriefing for every played mission), (3) received a traditional course on privacy risks and (4) received a course on a different topic (control condition). In a pretest-posttest survey we measured the risk awareness, attitudes and behavior of the pupils involved during the intervention. We will not elaborate upon the results here, but we will discuss some valuable lessons learned during this research.

3. Lessons learned during the evaluation study of Masterf.I.N.D.

We classify the pitfalls which were revealed during the research in two categories: issues related to the methodology and issues related to the intervention.

3.1 Issues related to the methodology

First of all, the design of quasi-experimental studies is necessary to have an idea of the (additional) impact of games such as MasterF.I.N.D. on the awareness, attitudes and behavior of the pupils involved, that is to assess the effectiveness of the game. The assessment is only valid if the implementation of the intervention is as controlled as possible trying to ensure internal validity, while still in an authentic setting, assuring the external validity of the research. However, when assessing the effectiveness of an educational game in a quasi-experimental setting, one needs to decide what the control group should be. Experts in educational sciences and experimental designs prefer the inclusion of a control group in which pupils are performing another educational activity than the tested game (All et al., 2014; Clark, 2007). This comparison enables the researcher to make conclusions about the impact of the game compared to a traditional course. However, when comparing the game with a traditional course, scholars have been confronted with the particular educational activity in the control group. What exactly is a 'traditional course'? And should the subject of the game be adapted to a traditional course or conversely?

In the case of MasterF.I.N.D. we had to change an existing, evidence-based traditional course (Vanderhoven et al., 2014a) according to the game content to have a good control condition. This way of working is rather absurd, as it would be more logical to develop the game based on the content of the traditional course, which was already proven to be effective in previous research. However, as the game was already developed when the study started, this way of working was not possible.

Second, a game may not only be compared with a traditional course, but also with the same game including other content. Including an extra condition with the same game and other content controls for differences in attractiveness of the game-based learning forms and is relevant in order to examine the motivations of the pupils, rather than knowledge acquisition (All et al., 2014). Scholars have been struggling with the issue to ensure comparing the same game irrespective of specific content. Nevertheless all conditions should be as much as possible comparable and may only differ on the tested key element (All et al., 2014).

In the case of MasterF.I.N.D. this was again not possible. The game was especially developed based on the content (e.g., including a fake SNS), and changing the content would not have made sense. Therefore, this sort of comparison was not possible as it was not taken into account during the development process.

Third, when implementing an intervention with an educational game in a classroom setting, several context aspects influence the impact of the game (Joy and Garcia, 2000). Often, games are assessed as if they are tested in an isolated labo-setting. However, in a less controlled classroom setting, several confounding variables may influence the impact of the game: the role of the teacher, the classroom characteristics, peer influences, specific implementation decisions, etcetera (Brom et al., 2012).

In the case of MasterF.I.N.D., the game was tested in a classroom setting and two extra conditions were included: one with and one without teacher involvement. This decision was made based on previous literature and findings about teacher guidance when using educational technology (Montrieux et al., 2014; Prensky, 2001). However, several other decisions could have been made, as the developers did not put forward any implementation guidelines and therefore it was not clear how the game should have been implemented in a classroom setting.

Finally, during the MasterF.I.N.D. evaluation it became clear that it is hard to choose all the right outcome measures to assess effectiveness, an issue that has been raised before by Bellotti et al. (2013). In our study we did a pre- and posttest measurement of several important dependent variables (awareness, attitudes, behavior) and possible covariates (motivation, flow,…). Assessing games in general involves investigating motivation and learning impact, but typically, depending on the type of game other constructs are focused on. Attitudes are most often assessed in entertainment games, whereas learning impact is commonly investigated in educational games (Prensky, 2005). Studies focusing on games therefore addressed most often affective and motivational outcomes and knowledge acquisition, but to a lesser degree skills, behavioral change and psychological or social outcomes (Hays, 2005). MasterF.I.N.D. is an educational game with a focus on changing attitudes and behavior, which appears to be a rare case.

3.2 Issues related to the intervention

With regard to the intervention, based on our experiences with MasterF.I.N.D., we argue that there are three important conditions for effective implementation of a game such as MasterF.I.N.D.: 1) a good game with a qualitative content, 2) a technological solid game, and 3) a good design and clear implementation guidelines.

First of all, the content of the game is important. The content needs to be supported by a theoretical foundation and by the need of teachers and pupils (Nation et al., 2003). In the case of MasterF.I.N.D., this meant that ‘privacy risks on SNS’ needed to be a topic that was necessary to teach to pupils, was felt as an important topic to teach for teachers and was exhaustive with regard to the topic of online safety. We quickly noticed that Child Focus had built the game about privacy risks without any theoretical foundation, nor did they base themselves on the requirements and needs of pupils or teachers. Research shows that there are more risks than privacy risks when it comes to social network sites, that need to be tackled in schools and that were not part of the game, such as cyberbullying, sexual solicitation, content risks or commercial risks (e.g., Vanderhoven et al., 2014).

Second, the game needs to be technological solid: it should satisfy the expectations of teachers and pupils, and it should not crash. With regard to MasterF.I.N.D, this condition was satisfied. The game included a fake SNS, which was expected by pupils and teachers with regard to the topic of the game. Moreover, the game was very stable.

Finally, a good design and clear implementation guidelines are necessary. As Prensky (2001) states: ““If some of these games don’t produce learning, it is not because they are games, it’s because those particular games are badly designed”. This aspect is often overlooked during the development phase. While the developers of MasterF.IN.D. clearly had attention for specific design aspects, such as the lay-out (they asked pupils and teachers for feedback during the development process), they overlooked several important usability aspects.

Pupils reported that there was way too much text in the game, they did not find the 'search' button in the social network, etcetera.

Moreover, Child Focus claimed that the game could be used both individually at home, and in class. However, as stated before, they did not give any implementation guidelines about how the materials could be used in class. This is one of the main obstacles that make it difficult to integrate games in the classroom: as games are often not developed for implementation in class, they are not compatible with the curriculum and the structure of courses (Wastiau et al., 2009). This is particularly the case when it comes to cross-disciplinary subjects such as online privacy.

As becomes clear, developing a digital game based learning environment leads to a series of decisions one needs to take. An agile way of developing is recommended, taking into account a continuous conversation between developers and research partners from the introductory brainstorm on, in what can be called a participatory design (Chu et al., 2015; Goodwin, 2009). Of course, every problem stumbled upon navigates research decisions and thereby will jeopardize the validity of the research results (Vanderhoven et al., 2015).

4. Suggestions for further research

We argue that the main problems with the evaluation of Master F.I.N.D. were caused by the lack of research input when developing the game. User research during the design-phase would have made the game more fitting for the aims that were put forth, and would have guided the evaluation phase once the game was developed. We argue that involvement of the user in the context of design-research is necessary if one wants to develop an effective educational game. Although this technique is known with educational researchers, developers of educational games are often not aware of the importance of user research during the design-phase. Therefore, ideally, user research conducted by user researchers should also result in design principles and implementation guidelines, that are easy to communicate towards industry and developers, to increase chances of success when developing other educational games.

There are well-described methodologies that meet the requirements of user research as described above such as the design-based research methodology. The design-based research methodology is a well-used research approach in the Learning Sciences (Barab and Squire, 2004; Brown, 1992; The Design-based Research Collective, 2003) and relies on multiple sources of evidence, both quantitative and qualitative, which are triangulated (Cohen, 2011). Yet, although a design-based research approach includes several well-established research methods and is based on existing norms for sampling, data collection and data-analysis (McKenney and Reeves, 2013), the approach as a whole is fairly recent (Anderson and Shattuck, 2012). The methodology has been defined by Wang and Hannafin (2005) as:

> *"A systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real world settings, and leading to contextually-sensitive design principles and theories"(p. 6-7).*

Following this definition, the procedure of design-based research, iteratively involves four sequential steps (Reeves, 2006): (1) the analysis of practical problems, (2) the development of solutions based on existing knowledge, (3) evaluation research of the solutions in practice, and (4) reflection to produce design principles.

Both the definition and the procedure reveal important characteristics of design-based research which show the significance of this research method to overcome the problems with the evaluation of Master F.I.N.D described above.

First of all, developing learning materials in a design-based research starts from problems that are both scientifically and practically significant, as revealed in an initial problem analysis (Edelson, 2002; McKenney and Reeves, 2013). This ensures qualitative content that is theoretically founded and based on the needs of pupils and teachers. Moreover, this first phase pinpoints the goals that should be put forward and therefore the measures that will be needed to take into account during evaluation. In the case of Master F.I.N.D the content of the game would have been more exhaustive and theoretically founded. That way, it would probably also have been more comparable to the traditional course of Vanderhoven et al. (2014a), thereby facilitating comparison in a quasi-experimental evaluation study after development.

After the initial development of the educational game, the design-based research involves multiple iterations of testing and refining of problems, solutions, methods and design principles (Phillips et al., 2012), while sustaining a collaborative partnership between researchers and practitioners (Anderson and Shattuck, 2012). These iterative evaluation studies should lead to a technical solid game with an appropriate design and an optimized usability and learning impact. As the research needs to be conducted in real educational contexts, and not in lab-settings, collaboration with practitioners during this testing phase also ensures attention for context variables, such as the role of the teacher and the adoption of the game in a classroom setting.

Finally, the design-based research method mostly stands out because of the goals it puts forth: it seeks to bridge theoretical research and educational practice, thereby resulting in both a societal contribution, such as educational games and an increase of theoretical knowledge (McKenney and Reeves, 2013; Reeves, 2006; Vanderlinde and van Braak, 2010). Therefore, next to the development of practical solutions, design principles, or 'prototheories,' that help communicate relevant findings for other researchers and practitioners are proposed (The Design-based Research Collective, 2003). In the case of MasterF.I.N.D., both implementation guidelines (e.g., how to implement the game in a classroom context?) and design guidelines (which aspects of the design are critical for both user satisfaction and learning impact?) could have been formulated. That way, both teachers that want to implement the game in the classroom and developers that want to develop educational games on online safety, would have the necessary support.

5. Conclusion

Based on a quasi-experimental evaluation study of the game called MasterF.I.N.D., we described several pitfalls one can encounter during evaluation research of game based learning, both with regard to the methodology used and with regard to the intervention. We argue that the design-based research approach can offer a solution for the aforementioned problems. By including developers, researchers and the user of the educational game (teachers and pupils) during the full design process, one can guarantee a final game that is theoretically sound, with qualitative content, that is technically stable and satisfying the needs and requirements of the final user and obtaining its goals. Moreover, this method would result in design principles for future developers and implementation guidelines that can be used by teachers to guide their classroom practice.

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Concealing Education Into Games

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Abstract: Although educational games become an upcoming trend, their effectiveness, reusability and entertainment factor remain a challenge. Merging entertainment with education is a major issue as the game must not get in the zone of homework or else it will lose its enjoyable nature. Consequently, the user/student must not engage consciously into the learning process but through an indirect captivating course which will contain the educational elements that are required for his/her learning experience. These elements consist of educational material that an instructor wants to furnish the students, as well as techniques which the instructor will use in order to teach the subject. More accurately, educational techniques are based on pedagogical patterns described by pedagogues, child psychologists etc. In light of the above, the present work distinguishes four main roles in the creation of an educational game (a) the educational expert (pedagogue, psychologist etc.) who will provide the educational theories and instructional patterns,(b) the game designer or more generally the game industry (consisting of game artists, scenarists, audio editors etc.) who will provide games that follow the mindset of the given educational theories/patterns and render a customizable game prototype while maintaining its ludic and exciting manner, (c) the instructor who, in most cases with no game development experience, will integrate the educational content and customize the game to suit the class profile and (d) the learner who will use the games to enhance his learning experience. In this paper, we present the challenges of creating ludic and serious educational games, by means of cooperation between different domains such as game designers and educational experts. Based on the state of the art for educational game authoring tools we propose a collaborative authoring tool in which each role has a dedicated purpose and a suite of tools under a common information space.

Keywords: educational game, open authorable framework, ludic game design

1. Introduction

Educational games for children have been widely used in supporting learning in and outside of school and as a result a growing interest has appeared for the potential of digital games to deliver effective and engaging learning experiences (Hwang 2012). There is a variety of computer games and software that intend to assist users to achieve various educational goals. Moreover experts, teachers, parents and students increasingly consider technology as a complementary support for their education. Currently, ample research has been done in Serious Games that cover matters related to education, therapy for communication, psychomotor treatment and social behaviour enhancement. Zyda (2005) defines a Serious Game as: “a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives”. Serious Games for education and mental health can be combined to help learners with a range of impairments such as autism or attention and concentration deficits.

Educational gaming is a great platform that helps in motivating students to learn and is designed to teach students about a specific subject and/or skills. Prensky (2001) argues that children are naturally motivated to play games. Educational games are interactions that teach students goals, rules, adaptation, problem solving, interaction, all represented as a narrative. Such games give them the fundamental needs of learning by providing enjoyment, passionate involvement, structure, motivation, ego gratification, adrenaline, creativity, interaction and emotion. "Play has a deep biological, evolutionarily, important function, which has to do specifically with learning" (Prensky, 2001).

In general, computer games and other digital technologies such as smart phones or the Internet seem to stimulate playful goals and to facilitate the construction of playful identities. This transformation advances the ludification of today's culture in the spirit of Johan Huizinga's homo ludens (1949). In this context, this ludification can be also used in educational activities to strengthen the motivation and the engagement of the students.

Moreover, the narrative of an educational game plays an important role in its success. The story is the root of the whole gaming experience. Up to now, educational games have been usually created with a closed architecture and a single narrative, resulting in failing to provide a more personalized or customized learning procedure.

When the game industry and science combined, as in Kawashima (2015) "Brain Training" game for Nintendo, they were able to improve memory and analytical skills by creating challenges based on logic, numbers, and colour.

In this paper we present a framework for educational game creation based on the learner, educator, and parent empowerment concept. We present initial development of an Open Authorable Digital Adaptive and Ludic platform that aims to increase the effectiveness of serious games for experts (researchers, specialists), carers (teachers, trainers, parents) and users (adults, schoolers, pre-schoolers).

The rest of the paper is organized as follows. In section 2, we present current state of the art in educational matters and games. Section 3 focuses on the proposed system and finally, section 4 concludes and discusses future work.

2. Background work

Our research focuses on the integration of educational aspects into games, which calls for efficient collaboration between education/psychology expert and game designers. With the term "expert" we describe a phycology or pedagogy expert that will provide educational theory and learning styles based on abstract models upon which our games will be based. Under this scope, we search through state of the art educational game authoring tools to define the gap of communication between experts and game designers. Furthermore, we investigated educational theories and learning models which are already integrated into game infrastructure in order to establish a common space to base our communication.

2.1 Educational game authoring tools: Education experts - game designers

Augmenting education into games is a difficult task as here are certain boundaries that are set in order to keep the games entertaining. Although, there are plenty of game authoring tools developed in the last five years, they do not provide enough flexibility for experts, such as psychologist or pedagogues, to explain and digitize educational theories and learning styles to be used in game creation. There has been a great development in the communication and collaboration between the development team that consists not only from game designers, artists but also educators and pedagogues. Storytec (Mehm et.al, 2012), enhances the intercommunication of the different roles participating in the development team by introducing a unified authoring tool for all roles. In such way, it minimizes the involvement of programmers in most parts of the game development. The information that each role inserts, is visualized into a graph that is comprehensible by all roles. StoryTec is structured based on educational theories and learning styles such as a model similar to Kolb's Model of learners (Kolb, 1984) to categorize the users and knowledge space theory which make games more adaptive and surely educational. However, it does not give space to experimentation with different educational theories and styles. Pedagogues can define the learning path of the game but have to repeat this process for each one they create. ARLearn (Gonzales, 2012, Ternier, 2012) follows the same philosophy thus it is based on concrete techniques such as immersive learning and Kolb's cycle of learning. <e-Adventure> (Torrente and Blanco et.al, 2010) addresses the issue of experts/instructors' lack of technical background and develop a story-driven editor which facilitates a visual modeling language editor to describe the game. Although this is a useful and easier way to describe a game story without been accustomed to programming, it is not suitable for describing an abstract educational pattern that will be followed throughout the game.

2.2 Learning theories

In order to minimize the communication gap between experts (psychologists, pedagogues, etc.) and game designers we have to find a common language. According to Becker (2005), games embody the fundamental elements of Gardner's theory of multiple intelligence (Gardner, 1997). Gardner proposes eight primary forms of intelligence: (1) linguistic, (2) musical, (3) logical-mathematical, (4) spatial, (5) body-kinesthetic, (6) intrapersonal (e.g., insight, metacognition), (7) interpersonal (e.g., social skills), and (8) naturalistic (sensitivity to natural phenomena, and classification skills). Furthermore, there are features found in the literature as the Zone of Proximal Development by Vygotsky (1987) and the Flow Theory by Csikszentmihalyi (2014), describing the ratio of learner's skills and challenge level in order to keep the game interesting and challenging that are already features of the game creation mind-set, although there are ways of enhancing this feature by using the user profile mechanism to adjust the difficulty of the games.

The research community has developed many models of digital learning ecosystems but few of them put into practice. Nevertheless, all recognize instructors, students, ICT industry and educational content as core entities. As (Pettersson, 2013) refers, there is a gap between the individual teacher and the ICT companies. Teachers are hesitant to use ICT and companies aim to sell directly to municipalities and not individual instructors. This gap has negative consequences on both ICT industry for not having enough feedback and instructors for not having personalized educational content for their students.

In our approach, we use the parallelism described by Becker (2005) to create 7 aspects of game output that, combined with a basic set of additional information common for both education and games (such as rewarding, evaluation, feedback, etc.), will be used by the expert to describe the educational game's specification in terms of their own field and easily translate those terms into rules for game creation to be used by the game designers.

By dividing game aspects into those subsections, expert can describe any existing educational theory or learning style based on the target group of the AEGM-P. Each of those modules has its own settings in terms of how it will be utilized. Experts can enable one or more modules and set them up with either strict conditions or just enable them and let game designers use them unconditionally. For example, enable visual utility but limit moving items on the scene to one and scene colours to grayscale because the target group refers to children with Attention Deficit Hyperactivity Disorder (ADHD).

3. Methodology

This initial design of the Open Authorable Digital Adaptive and Ludic platfrom focuses on setting up the operational model for carrying out the codification of educational theories and learning styles as well as the generation of ludic, narrative, and educational games according to needs, abilities and educational goals. This design exhibits several novel characteristics, which differentiate the games created with this platform from other forms of educational computer games and platforms. To be more specific, the platform is not only concerned with educational computer games, but also seeks to provide a guided learning environment for both educators and learners, that is play-based and/or story-telling by combining narrative and ludic for harnessing knowledge. Consequently, its primary focus is to enable educators and learners with the use of ludology and narratology to perform learning tasks and provide an effective and engaging learning experience. To achieve this, the platform builds on a range of technologies, including semantic web, game engines and advanced human-computer interaction. Furthermore, it adopts a knowledge-based, reuse-oriented and natural user interaction model to attain high quality during the performance of learning tasks. As such, we present a platform for educational games aiming to increase the effectiveness of serious games for experts, carers and users with or without mental, physical, or social technological disadvantages.

4. General architecture

The general architecture of the Open Authorable Digital Adaptive and Ludic platfrom includes tools and services for (a) enabling experts to codify pedagogics, learner personas, in-game analytics and NUI device data into game guidelines, (b) allowing carers to either parameterize existing serious games to fit specific educational session needs or create their own educational and/or rehabilitation games based on the experts codified guidelines, and the game objects provided by the platform in an easy and without reliance on software developers (c) permit learners to customize games according to their preferences and desires and play games alone or in groups with or without carer's supervision and (d) enable experts or carers to evaluate playing sessions and come to pedagogical and recovery conclusions / decisions as well as allow game guidelines to be updated from in-game metrics and learner choices while playing.

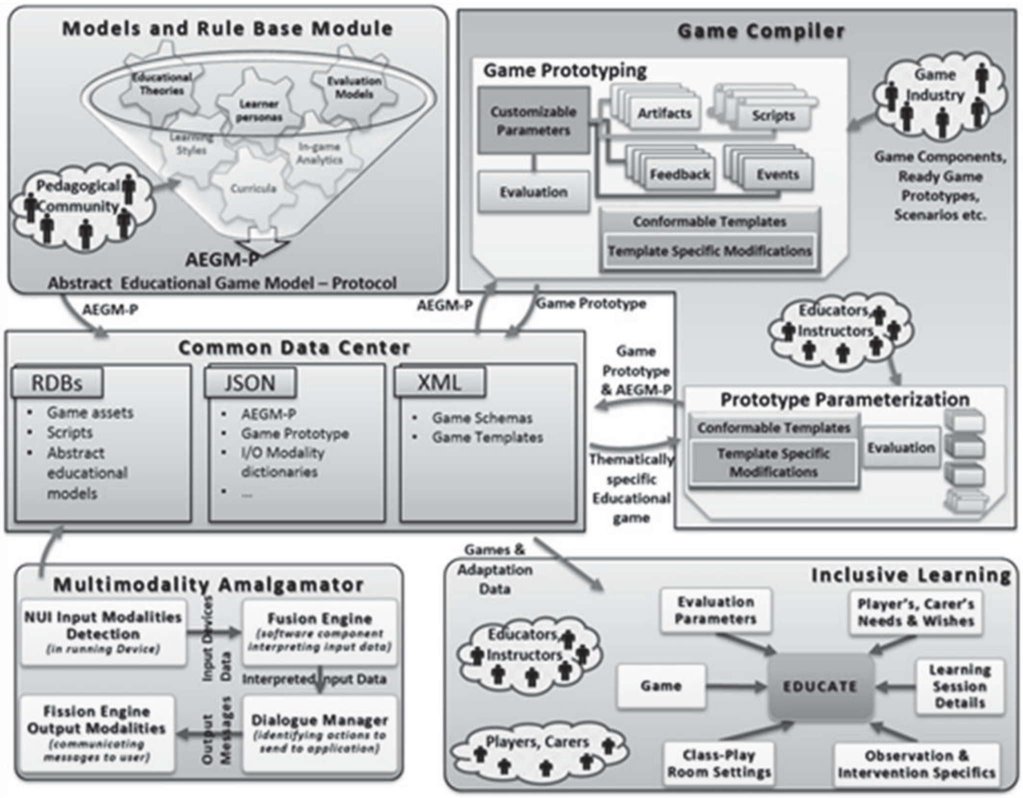

Figure 1: General architecture

A main role in defining the Abstract Educational Game Model- Protocol (AEGM-P) is fulfilled by educational stakeholders, i.e. experts, educators, carers and learners. Central to the platform is the Common Data Center (CDC), which is a repository for all different types of data such as RDBs, XML, OWL, Json etc. and supports solutions to gather, store and access the relevant information in a unified way. Around the CDC are all the main modules(see of the architecture: (a) the "Models and Rule Base Module (MRB))", (b) the "Multimodality Amalgamator (MA)", (c) the "Education – Training Session Module (ETS)" and (d) the "Game Compiler Module(GC)". Several tools and services support the functions of each model. In more detail:

- MRB**:** include tools and services for sub-ontology of educational theories, learning styles, and pedagogical methods, sub-ontology of learning personas, cognitive and physical limitations, and association to game modifications and an inference engine and API to allow update from in-game and educator interfaces.
- MA**:** provide a device detection mechanism, a fusion engine for interpreting input data and a fission engine for communicating output to the users.
- ETS**:** include tools and services for setting up a learning session in real life conditions, and for observing, intervening and evaluating the educational session. Smart data analytics will provide information to modify the games to enhance their learning outcomes for individual learners, and to adapt to their varying needs.
- GC**:** includes tools and services for creating serious game prototypes according to educational, learner and real site specifies. It also includes tools and services for personalizing the game prototypes to fit educational and user needs.

4.1 Concealing educational aspects into games

The purpose of our framework for educational game creation based on the learner, educator, and parent empowerment concept is to provide the means (tools and services) to allow: (a) experts (researchers, specialists) to codify the educational theory's attributes, (b) carers (teachers, trainers, parents) to parameterize and thus personalize education through games and (c) learners (adults, schoolers, pre-schoolers) to adjust their education though games to their specific preferences.

The initial development, presented in this paper of the Open Authorable Digital Adaptive and Ludic platform that aims to increase the effectiveness of serious games, addresses the educational aspects of a game through all its modules i.e. the MRB, MA, GC, and ETS.

With the use of the platform's modules experts can create (AEGM-P) which will be used as a guide to create game prototypes that are following specific educational theories (MEB module), carers can parameterize game prototype to suit specific educational needs according to target audience (GC module), and learners can personalize their education (ETS module).

4.1.1 Educational aspects and the MRB module

This module enables experts to transform known educational theories and learning styles into digital data which will establish an AEGM-P. Abstract educational game protocols contain information about the game creation in means of material design (e.g. which colours, audio, motion are allowed for a certain type of learning group) as well as scenario based information (e.g. games type, rewarding methods etc.). This information is used as a guide to create game prototypes that are following specific educational theories.

In more detail, the MRB module (see Figure 1, Figure 2, Figure 3 and Figure 4) is accountable for systemize / codify the various elements of the educational theories and learning styles. This is achieved by imprinting the theory's elements using a tabbed stepwise process. Apart from the first step, that imprint basic information about the theories, the process has no strict order of step execution. The codification process that has been developed in different steps and tabs gives the user the capability to define the theory elements in an organized and clear manner. The educational theories and learning styles imprinting is performed by the role "Educational Expert". The different groups of data that have been developed for imprinting the theory's elements are demonstrated in Figure 2, Figure 3 and Figure 4 below. In more detail, the theory's imprinting elements elucidate in:

- Step 1 - "*AEGM-P Basic Info*": records general data such as Name, Short Description, Educational Theory based upon, as well as Template Author name and Creation Date that are automatically inserted from the log-in account information. All the above data is part of step 1, of the codification process, and refers to AEGM-P basic details (see Figure 2). Once the user has completed step 1 proceeds to the next step. Each completed step is marked completed with the visual effects of gray color step name and the symbol "√" next to the step title. This visual aids enhance user interaction and augment user guidance through the step and tabbed process of codifying the educational theory.

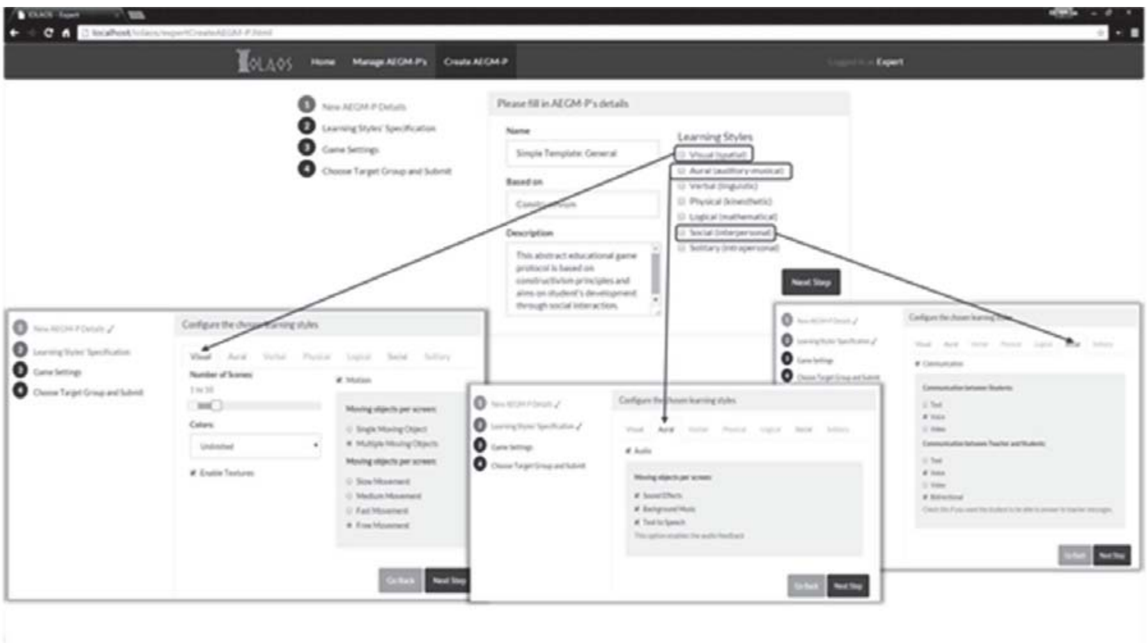

Figure 2: MRB module: Codifying educational theories step 1: Basics & step 2: Learning style specs

- Step 2- "Learning Style Specifications": records data concerning the learning styles such as Visual, Aural, Verbal, Physical, logical, Social, Solitary specifications. The learning style specifications that will be defined depend upon the decision made by the educational expert at step 1 where she / he has defined which styles will be involved in the specific AEGM-P. Figure 2 demonstrate the specification of Visual, Aural and Social styles that have been chosen by the expert at step 1.

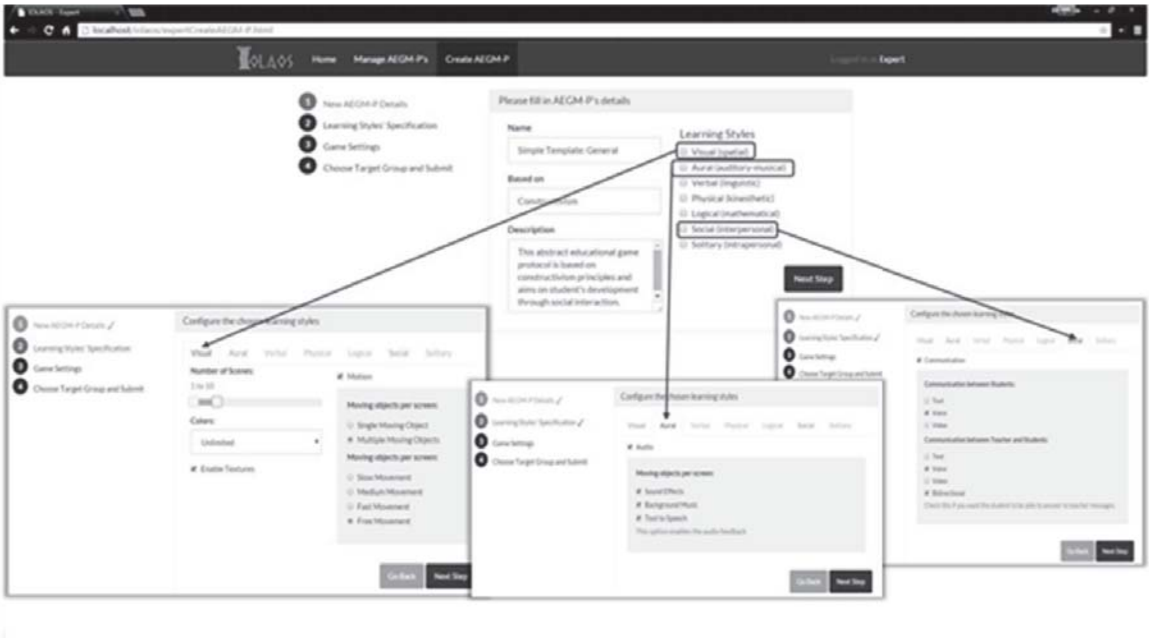

Figure 3: MRB module: Codifying educational theories step 3: Game Settings

- Step 3- "Game Settings": records data concerning with Evaluation, Feedback, Reward, Penalties and Controls aspects. At this step the user is provided, by the system, with pre-selected choices that come from the educational theory specifics that the AEGM-P is based on at step 1 and from the Learning styles that have been chosen at step 2. In our example the chosen theory is Constructivism and the styles are Visual, Aural and Social. Based on these choices the system proposes Visual and Aural Feedback and Rewards, no penalties as the theory does not support them (see table 1) and in-game evaluation. The user (educational expert) is allowed, by the system, to alter these settings and define the AEGM-P as it best suits its educational goals and necessities.
- Step 4- "Target Group": records data concerning learner's age or school grade, and Special Abilities. By defining such information about the learner the system provides the means to further personalize the educational game and thus enhance the learning process.

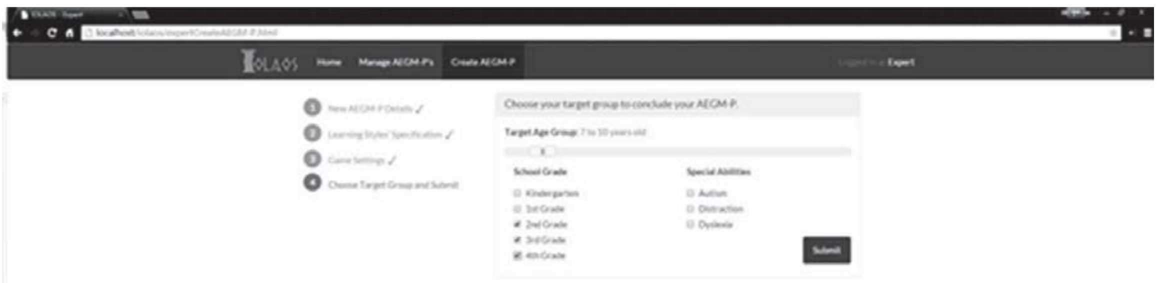

Figure 4: MRB module: Codifying educational theories step 4: Target group settings

4.1.2 The GC module

The game compiler module consist of two sub-modules, the game prototyping sub-module and the prototype parameterisation sub-module (see Figure 1). The game prototyping sub-module of the platform is used by game designers as well as by teachers which want to submit their game prototypes and ideas. The game editor tool within the game prototyping sub-module provides an easy way of game creation based on one or more AEGM-Ps. The game creator chooses which protocol or protocols his game will follow and the editor makes sure that the rules of the protocol are followed throughout the creation. If a rule is violated the game creator is notified by the system in order to make the appropriate changes.

The editor provides an easy-to-use interface for making several types of games. The creator has to define each scene's background, items, characters, rewarding, feedback, evaluation and the rules/scripts that define the purpose of the game (see Figure 6 and Figure 7).

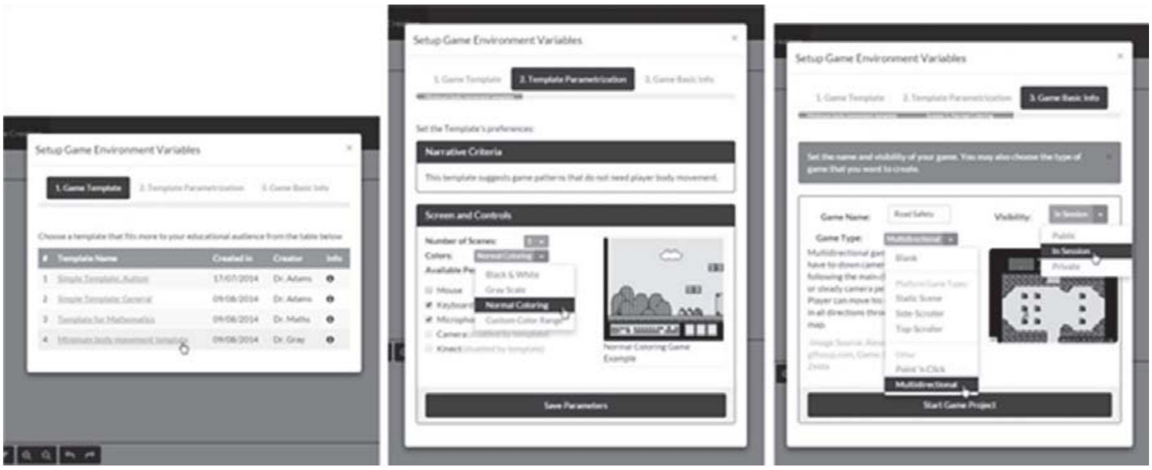

Figure 5: The AEGM-P tailoring

When the game prototype is complete a JSON file is created upon save and is uploaded on the system server repository containing the game environment, the game components and their scripts as well as the AEGM-Ps which the game is based on. The game prototype is playable and can directly be used by the teacher in a game session (ETS module). However, the teacher can use the prototype parameterisation sub-module to edit the game and modify it in order to bring it closer to the target group's interests, preferences and skills. In more detail, the teacher can modify the game prototype to sharpen its effectiveness based on his knowledge of the group he/she wants to address it to and switch on/off evaluation modules which are needed or not for his evaluation process (e.g. number of wrong moves, time spent in-game etc.).

Prior to the Game creation the user chooses a predefined AEGM-P that suits its game criteria and proceeds to tailor this abstract protocol to the specific necessities of its current game. Figure 5 shows the platform's elements that enable the user to tailor the abstract educational template. Elaborating, the user chooses game creation which triggers a series of actions before the actual game construction. Initially the user chooses the predefined AEGM-P (see left screen of Figure 5), and then tailors the AEGM-P to suit the specifics of its game within the educational boundaries that the chosen AEGM-P stipulates.

Once the AEGM-P has been customized the user proceeds to construct the actual game with the use of the game creation editor tool provided by the platform (see Figure 6). The game editor provides the user with a number of tool sets that allow a ludic, step wise, effortless, straightforward and uncomplicated game creation. These toolset assemblage includes (a) a game object tank with predefined game objects, scripts, and backgrounds as well as facilities for custom object creation, (b) game scene management facility with scene navigation, addition and deletion, (c) game canvas management with gridding, sizing, locating options etc. and (d) game construction previewing facilities.

Upon completion of the game construction the user proceeds with the construction of the evaluation, rewarding, feedback etc. scenes according to the specifics defined at the AEGM-P that the game is based on (see Figure 7).

Once the game prototype is created and uploaded at the system repository it is available for use by all authorised users. Teachers can use the game prototypes as is or they can choose to parameterize them according their educational needs.

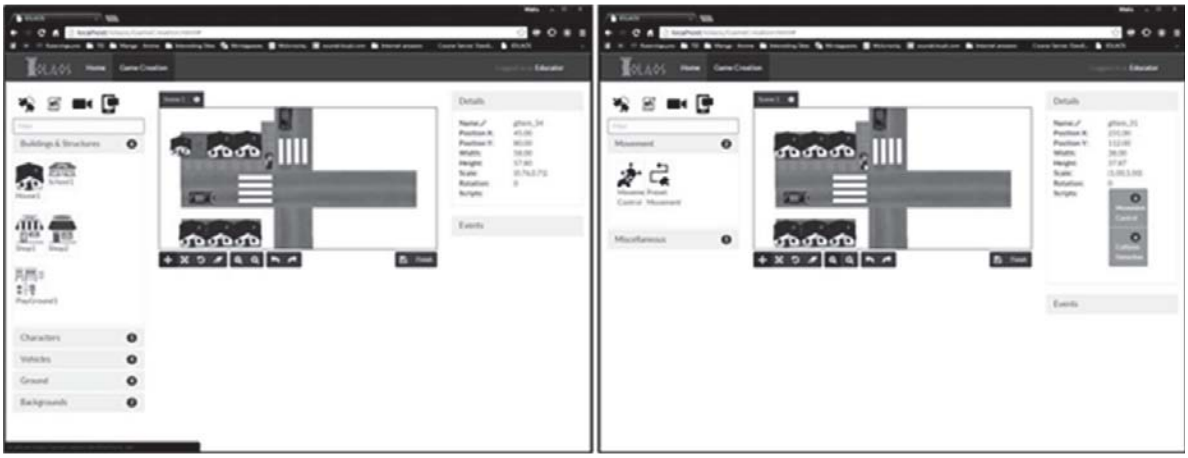

Figure 6: The GC game prototyping sub-module: Create game scenes

Figure 7: The GC game prototyping sub-module: Create rewarding scenes

4.1.3 The ETS module

The ETS provides the educator with the ability to fully manage learning sessions according to individual, group or class requirements every time she/he needs to run an educational game. The ETS module has several aspects and viewpoints. Teachers enable game sessions, with or without live observation and data storage features, they initiate game sessions and invites students to participate. Session manager distributes the game data to every invited student that joins and establishes a connection with the clients in order to receive game information and handle communication between players and the tutor. Students get into game from their devices, load the game data and start playing the game (see Figure 7 and Figure 8). The controls of the game are different based on the users client device or can be strictly specified by the teacher on the prototype parameterisation state. More specific the educator can determine, (a) Players and/or Group, (b) Marking / Evaluation Specifics / Procedure, (c) Session Statistics, and (d) Session parameters. She/he can also interrupt and save learning sessions in order to be completed in the future.

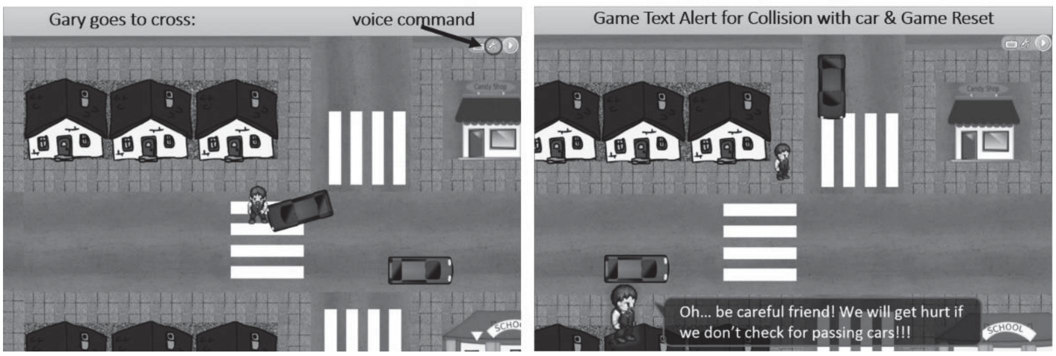

Figure 8: Play scenario: Collision with car

Figure 9: Play scenario: Successful crossing

5. Conclusion

In this paper we have attempted to sketch the organizational underpinnings of our platform, presenting a pilot effort that aims to build an open authorable framework for educational games for children. Our primary design target is to set up an operational model for carrying out the codification of learning styles, educational theories, pedagogical methods and evaluation models as well as the generation of ludic, narrative, and educational games according to needs, abilities and educational goals along with supporting his model with appropriate software platform and tools. Under this scope, we investigate the gaps between educational experts and game designers in order to find a communication basis for the two most valuable yet completelly different aspects of educational games. By identifing educational models which already exist in the concept of games, we analyse and develop an operational model for carrying out the codification of learning styles and educational theories. Finally, we tested the system's sequential process of creating an educational game from scratch with the scenario of a simple road safety game.

The flexibility which AEGM-P provides, enables education experts to provide concrete information about the game based on their knowledge of educational theories and learning styles, as well as define specific information based on the game's target group to game creators in a form which is compiliant to their domain. Furthermore, experts can specialize their models based on the target group's age, special abilities etc. Consequently, game creators are provided with domain-specific information thus the process of game creation is not restrained by communication issues. Finally, the created AEGM-P affords reusability by its architectural abstraction.

Ongoing work covers a variety of issues of both technological and educational engineering character. Some of the issues to be addressed in the immediate future include: (a) Elaborate on the Inclusive Educational-Training module (ETS), (b) Further exploration of learning styles, educational theories, pedagogical methods and evaluation models in collaboration with expert and educator professional associations so that our AEGM-P model can be customizable enough to describe any of the above, (c) Run various use cases in vivo with the guidance and involvement of expert and educator professional associations in order to measure the effectiveness of the digitalized learning styles and educational theories and (d) Enhance ludology aiming not only to children experience, but also to experts and teachers.

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Exploring Group Cohesion in Massively Multiplayer Online Games

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Abstract: In this study we focused on the identification of factors involved in the cohesion of Massively Multiplayer Online Games (MMOGs) groups. We operationalised cohesion as the forces that keep the group together and the links between group and members. We explored the perceptions of players through a mixed methods research approach, combining qualitative data from interviews and quantitative data from a survey. Our main findings involve the identification of social and achievement oriented factors relevant to the cohesion of the group. Social factors were relevant to the social and interpersonal relations among members, and the identification with the ideology and interests of the other members. Achievement oriented factors involved the benefits of the group for the achievement of the players' own individual goals and progress in the game, the accomplishment of group tasks, the help and support from the group, the quality of collaboration, participation in decision-making processes, justice, and fair distribution of the rewards. We further compared group cohesion with the satisfaction of the players by their groups. Our findings suggest that group cohesion and satisfaction are strongly related. Group cohesion is particularly critical for the development of a common knowledge space and the emergence of effective collaborative learning processes. The implications of this study involve the design elements that could promote cohesion in virtual environments, or the indications to be monitored by educators or coordinators employing game-based learning, for further timely interventions, so that a learning and gaming experience can be supported and enhanced.

Keywords: massively multiplayer online games (MMOGs), group cohesion, collaborative learning, games, virtual teams

1. Background

Massively Multiplayer Online Games (MMOGs) provide a remarkable venue for studying group organisation and group members' behaviours and attitudes in a virtual setting. MMOGs are dynamic, interactive, collaborative, motivating and engaging environments, where players collaborate and coordinate in order to progress in the game and achieve goals, form and manage groups, and construct the community of the players. Groups, presenting a rich relational and interactional space, have been one of the main units of analysis in the social study of MMOGs. They may have different names in different MMOGs (e.g. “guilds”, “clans”, “tribes”, “corporations”), but they share certain common features: they are usually formed with the perspective to endure over a long time, build links among members, accomplish multiple group tasks and progress as a group.

The potential of MMOGs to inform the design of learning environments and the need for further research has been recognized over the past few years (Carron et al., 2007; de Freitas and Griffiths, 2009; Dickey, 2007; Riegle and Matejka, 2006; Steinkuehler, 2008). Groups seem to play a critical role for this learning potential, the progress and the learning process in the game. They provide a framework for participation in communities of practice (Oliver and Carr, 2009; Wenger, 1998), with a shared domain of interest defining their identity as players, commitment, joint activities, helpful relationships, shared resources, practices and information, sustained interactions, and the acquisition of expertise (Nardi and Harris, 2006).

Building upon research on the success and failure of MMOG groups, we focus on the concept of group cohesion. Factors such the size of the group, character class and level balance, group organization and structure, the affective component and liking the other group members, and the communication media used, have been identified as factors relevant to the success of a group (Ducheneaut et al., 2007; Pisan, 2007; Williams et al., 2007). The cohesion of a group seems to be one of the critical factors for the effectiveness of a group in work or learning environments, in both virtual and real-life settings.

Cohesion is particularly important for the development of a common knowledge space and the emergence of effective collaborative learning processes (Garrison et al., 1999). Group cohesion refers mainly to the forces that keep the group together, “the total field of forces which act on members to remain in the group” (Festinger, 1950, p. 274), the links between group and members: the motives, the sense that they are part of a group, and the commitment. It has been linked not only to the interpersonal relations among the members and “the attractiveness or unattractiveness of either the prestige of the group, members of the group, or the activities in which the group engages" (Festinger, 1950, p. 274), but also to the commitment of the group and the individual members to the task which is related to work performance (Carless and De Paola, 2000).

Our objective, in this study, is to explore the concept of cohesion, focusing on the MMOG groups, which are the basic collaborative units of the players. Better understanding of the factors that contribute to or undermine the cohesion of a group could help inform the implementation of game-based learning and the design of more effective collaborative learning environments. We attempt to explore the concept of cohesion and the factors involved through a mixed-method research, based on qualitative and quantitative data. Our main findings involve the emergence of social and achievement-related factors that contribute to the cohesion of the group, and the relation of the group cohesion with the satisfaction of the members.

2. Method

For this study we employed a mixed method research approach, combining qualitative data from interviews and quantitative data from a survey. The interview and questionnaire data collection took place in 2010-2011. The data were gathered as part of a broader study on learning practices and outcomes in MMOGs. For the qualitative approach we conducted 20 semi-structured individual interviews and 2 focus groups (group interviews) with players of different MMOGs. For the quantitative approach, we constructed a questionnaire based on concepts involving group cohesion as they emerged from the analysis of the qualitative data. It was addressed to players aged over 18 of any MMOG. The most common MMOGs the players reported playing were: Lineage II (L2), The World Of Warcraft (WOW), Diablo 2, Eve Online (EVE), Tribal Wars (TW), Age Of Conan (AOC), Final Fantasy (FF), Rapelz, Ikariam, Lord Of The Rings Online, and Aion. The respondents were mainly from Greece. The demographics of our interviews and questionnaire samples are summarized in Table 1 and Table 2.

Table 1: Demographics of interview participants

Interview Participants	
Characteristic	**f**
Age	
<18	7
18-24	3
25-34	13
35-44	3
45-54	1
Education	
High school	8
Vocational training	6
Higher education	10
Postgraduate or more	3
Gender	
Male	21
Female	6
N=	27

Table 2: Demographics of survey respondents

Survey Respondents		
Characteristic	**f**	**rf (%)**
Age		
18-24	108	45.4
25-34	97	40.8
35-44	28	11.8
45-54	4	1.7
> 55	1	.4
N=	238	
Education		
High school	90	38.3
Vocational training	36	15.3
Higher education	65	27.7

Survey Respondents		
Characteristic	**f**	**rf (%)**
Postgraduate or more	44	18.7
N=	235	
Gender		
Male	214	91.1
Female	21	8.9
N=	235	

Most of the interviews were conducted face-to-face, two via instant messaging, and two via voice-over-IP services. Their duration was approximately from 1 to 2.5 hours. The interview participants were co-players in MMOGs one of the authors participated, or they had responded to a call for participation in the study which was published in various game, research, or education-related online fora. The interview questions used for this study were relevant to the practices, the processes, the benefits, and the shortcomings of the player's group (e.g. "*What are the benefits for you of being in a group?*", "*What happens in the group if you fail in a group task?*", "*How do you reach decisions in your group?*", "*Have you seen a group disband? If so, what were the reasons?*"). All the interviews were transcribed, coded, and then analysed. The first phase of the coding was data-driven and pattern-driven, identifying themes and issues as they emerged from the data. The patterns (codes) that emerged form this phase were: Members leaving the Group, Disadvantages of Groups, Benefits of a Group, Successful Group, Unsuccessful Group. The second phase of the coding was model-driven, based on the concepts relevant to group cohesion as described in the research background, such as interpersonal relations, the tasks of the group, commitment to the group (Creswell, 2003, p. 191; Gibbs, 2007, p. 86; Saldaña, 2009). The qualitative analysis software QSR Nvivo 8 was used. The analysis is discussed in the results section of the article. Excerpts of the interviews are cited during the discussion, as evidence, for addressing the reliability and the validity of the qualitative analysis (Silverman, 2005, p. 224).

Based on the issues and concepts that emerged from the analysis of the qualitative data, we constructed a questionnaire including questions (five-point scale) such as "*My team helps and supports me in the game*.", "*There is a strong bond among the members of my team.*", "*My team succeeds to the goals it sets.*" All the survey items used for the study described in this paper and descriptive statistics are included in Table 3. These items are part of a more extensive questionnaire on MMOG preferences, motivations, game habits, and in-game behaviours. The questionnaire was delivered online, through the "Survey Monkey" platform. Responses were first analysed descriptively, for obtaining an overall view of the sample and the issues discussed.

We, then, constructed a new variable for *Group Cohesion*, based on items relevant to the *social environment* and the *achievements* of the group, since, as will be discussed in the results section, these were the two main trends that emerged from the analysis of the qualitative data. The items used for the construction of the new variable *Group Cohesion* were: Q1, Q2, Q4, Q5, Q6, Q7, Q9, Q10, Q12 (Cronbach's Alpha= .769).

Contrary to what one might expect, high group cohesion does not seem to always correlate with members' satisfaction. An indicative example would be the supporters of a sports team despite the low rankings of the team (Martin and Good, 2014). We, therefore, further compared the *Group Cohesion* variable with the latent variable *Group Satisfaction* which was similarly based on the survey items Q3, Q8, Q11 (Cronbach's Alpha=.708). For the statistical analysis of the survey responses the IBM SPSS 19 software was used.

3. Results

Through the analysis of the qualitative data, two main trends emerged, with respect to the forces or motives that keep the members in the group, and the factors involved in the development of a collective identity: a) social forces and b) achievement-related forces.

The social forces involved the social and interpersonal relations among the members, and the identification with the ideology and the interests of the other group members; the social interactions, the friendships, similar ideology, and common real-life interests seem to increase the bonds among members, while disruptions of such bonds may lead to disbanding of the group:

“In one tribe, there was a clique of nationalists. The other members, they were more low profile, more moderate, and they did not like them. So the tribe was disbanded”

“[...]because the game has to be fun. And when you are with others you can have fun. That is because you want the group to be good and tight [...]”

“[...]but I also think that your need for communication and chatting with others will make you join a guild – to register, to be a member, active or not – it doesn't matter. To get into the group, to greet other people, chat, and things like that”

Similarly, players recognized the benefits of grouping with respect to the achievement of their individual goals and their progress in the game. An extensive part of the game content is only available to groups, particularly in higher levels. Players have to group for exploring the content, progressing in the game, and confronting competition. The players reported that they remain in the group not only when it is socially active, but also when it is operationally effective: when it helps them progress their virtual characters and skills, through for example the participation in group activities, when they feel that the goals of the group are relevant to their own individual goals, when success in their goals is linked to success in group goals, when they feel that there is justice and fair distribution of loot and rewards, when they cooperate well with the other members, and when they feel that they receive help and support, as indicatively illustrated in the following interview excerpts:

“There was this older player, who was managing us and giving as the basic guidelines, answering our questions, and telling us how to complete the quests. He was making us something of a team”

“Up to a point, you can do things on your own in the game. But the more you progress, the more you need a group. At the end of the game, you can do nothing alone.”

“You always look for something better. For example, I had joined a small clan in the beginning. Then I went to the top clan of 2007”

We further examined quantitatively, through the survey, the issues, trends, and patterns that emerged from the qualitative analysis. The relevant items involved the attitudes of the players towards their groups and the group practices and processes. Results of these items provide indications that the players were, at that point, satisfied by their group. Only 3.5% (N=299) responded that they were not satisfied by the group. Also, the majority of the players (strongly agree, agree) responded that there are good social relations in their group (Q2) (80.2%), that they felt they could freely express their opinion (Q4) (79.9%), that their group supports their progress in the game (Q1) (71.7%), that they could discuss about topics irrelevant to the game, such as social issues, with their team-mates (Q12) (71.7%), that they are satisfied with the decisions made by the group (Q8) (62.9%), and that their group is successfully achieving its goals (Q6) (53%). More detailed descriptive statistics of the items are presented in Table 3.

The intensity of these forces (sociability and achievement) seems to be related to the satisfaction of the members. The correlation between the two variables (*Group Cohesion* and *Group Satisfaction*) was strong (r=.730, p=.001). The higher the perceived cohesion of the group, the more satisfied the players were by their group.

Table 3: Descriptive statistics of survey items

Items	Mean*	SD	
Q1 My team helps and supports me in the game.	3.82	.81	
Q2 There is social interaction and a friendly atmosphere among the team members.	3.97	.75	
Q3 My team is appropriate for my goals in the game.	3.75	.77	
Q4 I feel that I can express my opinion freely, in my team.	4.06	.79	
Q5 A failure of the team does not lead to arguments.	3.41	1.04	
Q6 My team succeeds to the goals it sets.	3.57	.76	
Q7 If I make a mistake, other members of my team do not make accusations against me	3.89	.78	
Q8 I am satisfied by the decisions made by my team.	3.71	.79	

Items	Mean*	SD
Q9 Reward distribution in my team is fair.	3.78	.99
Q10 There is a strong bond among the members of my team.	3.29	.91
Q11 I like my team.	1.76	.91
Q12 I can talk about issues irrelevant to the game with the members of my team.	3.93	.98
**1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly Agree*		

4. Discussion and conclusions

Attempting to explore the factors that contribute to the cohesion of a group in MMOGs, we identified factors that involve the social conditions in the group, the interpersonal relations and social interactions among the members, as well as instrumental and achievement-oriented practices and processes which also support the individual progress of the player in the game, participation in the decision-making processes, the material rewards, the help and support, the progress of the group in the game, success in group tasks.

The findings of the qualitative data analysis were consistent with the definition of cohesiveness described by Widmeyer et al. (1985, in Carless and De Paola, 2000) who focused on real-world sports groups. Widmeyer and colleagues conceptualized cohesiveness as a framework involving individual and group aspects and also task-related factors such as the goals and the objectives of the group, and social factors involving the social relations.

Our findings provide some insight on the elements of a multiplayer game experience that can support the effective cooperation among players and the sustainment of a good social environment, both of which are critical components for a successful multiplayer game for learning. MMOG groups constitute affordances of the game design. Their processes, practices, sustainability, and effectiveness though depend, to a large extent, on the players. Supporting and monitoring these processes and practices, either through the design of the game or during the implementation of a multiplayer game in an educational setting, could help identify or predict possible disruptions or hindrances in the group progress. It seems that factors such as the interpersonal relations of the players, grouping of people with similar interests, support for the development of friendships among the group members, linking of the individual goals, progress, and success with the goals, the progress and the success of the group, motivation and opportunities for the group to participate in group activities, ensuring a fair and just system for rewards distribution among the members, the possibility for the members to participate in decision making processes, and ensuring that the group provides help and support to each member, would add to the cohesiveness of the group in a multiplayer game.

For the success of an MMOG group, though, factors beyond the in-group practices, processes, and relational space, and even beyond the game environment will have to also be considered. These factors may impact positively or negatively the life of the group. Both the social bonds among the group members and also the effectiveness of the players and the groups in the game tasks may extend beyond the environment of the game. Groups may also communicate in web forums external to the game, or arrange face-to-face meetings. They resort to external websites and web forums for information and advice on how to become more effective and progress in the game. Real-life and real-world issues may cause members of the group to leave, as well as the broader community of the game and the behaviour of outgroup players, or strong subgroups in the group that may leave the group (Poor and Skoric, 2014). Such factors should also be considered when attempting to support the cohesiveness of an MMOG group.

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Multi-Devices Territoriality to Manage Collaborative Activities in a Learning Game

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Abstract: Game Based Learning (GBL) has positive effect on learners' engagement. Students feel more concerned and invested when the learning scenario and gamified elements are motivating. Usually, GBL environments can improve individual activities, particularly by adapting them to the learners' current knowledge or can support collaborative learning in multi-player environments. In our research, we consider complex scenarios where both individual and collaborative learning are addressed. In order to support these scenarios, we take advantage of various devices, allowing new features. Personal devices (tablets, mobile phones) co-exist with shared devices (collaborative tabletops). New learning usages emerge in these multi-device environments where learners can swap from virtual to real activities. In this context, new problems appear when one wants to design new GBL activities. One major issue refers to the combination of personal and collective workspaces. This notion also known as "territoriality" has been addressed in the literature, particularly in Collaborative Tabletop Workspaces. However, we need to extend and reconsider this notion when designing multi-device activities. For instance, providing users with both private and shared devices raises confidentiality issues. In this work, we thus present three facets to consider for the design of GBL activities in this context. The first facet concerns the devices topology: the adjacency map, the notion of personal workspace on a collaborative device, and the representation of the area allowing information exchange between two devices. The second facet concerns the new actions to define: how to allow the users to provide others participants with information, to present partial information on objects to others, how to move an object from the collaborative workspace to personal workspaces and how to control shared workspaces through individual actions. The third facet concerns the contextual visualisation of the objects involved in the learning tasks. This contextual visualisation can for instance allow the privacy of several characteristics of an object. The object can be totally visible on the user's tablet, but may be hidden to the others in the collaborative workspace (e.g. one can see his/her game cards face-up on the tablet view while the same cards are face-down on the tabletop view). These three facets are then used to design the scenario of a collaborative game to learn French grammar. The scenario takes place in a newspaper office, where learners should edit short features about their university news. This writing exercise is prepared individually and then a collaborative edition happens. In this activity, personal and collaborative workspaces are used with different devices supporting the activities. The proposed approach is therefore particularly adapted to the context.

Keywords: collaborative learning, personal workspace, collaborative workspace, tablet, tabletop, multi-device environment

1. Introduction

It is now commonly stated that Game Based Learning (GBL) has positive effect on learners' engagement (Hildmann et al, 2009 ; Kelle et al, 2011). Students feel more concerned and invested when the learning scenario is motivating, and this is particularly true with GBL scenarios (Pernin et al, 2014). With the evolution of the technology and the emergence of new devices, the complexity of learning scenarios mixing personal and collaborative activities is considerably increasing (Dillenbourg et al, 2007). Our research interest focuses on the improvement of collaborative learning with GBL environments. According to the results described in Dillenbourg (1999), collaborative activities require having individual and collective workspaces. This clear separation between individual and collective workspaces for collaborative activities taking place on tabletops has already been addressed through the "territoriality" notion (Scott, 2004). Currently, more complex learning scenarios in numeric environments, containing several kinds of devices (computers, tabletops, tablets), emerge.

Based on previous studies on collaborative activities, we propose to reconsider territoriality needs, taking into account the multi-device approach. We will address three research questions that are derived from this general objective. First, we need to select which devices are appropriate to support individual and collective activities for a learner. Then, we need to specify the interaction part, detailing how to work with personal or collective data, how to transfer them from personal to collaborative workspaces, or from collaborative to individual workspaces, defining the gestures and interactions needed for performing the basic identified actions. Finally, we consider the data visualisation part. As several people are involved in these collaborative learning activities, we may need to define views on several pieces of information where the information may be partly hidden to others. We therefore need to study what are the correct visualisations according to the user, his/her device and to the level of privacy of the data.

The second section presents the main results on which we ground our work. Previous research in the three different mentioned domains is briefly presented. We explain how personal and collective workspaces are used in a GBL collaborative activity; we give an overview of new devices offering new interaction forms; and we describe the territoriality notion that is linked with all these aspects. In section 3, we present our contribution. We describe our proposition allowing to extend the notion of territoriality in a multi-device environment. This proposition will be applied to the design a particular case study. In section 4, we describe this case study and explain how the three research questions are faced in this particular example. We finally conclude our paper by giving new ideas to reinforce this research work.

2. Related work

2.1 Collaborative game based learning

Collaborative learning is an activity where two persons or more (a pair, a group, a class, etc.) learn something (taking a course, solving a problem, etc.) together (face to face, through computers, etc.) according to Dillenbourg, (1999) definition. From this aspect, he describes different kinds of workspaces that learners need to exploit in collaborative activity. The first one is personal. Learners has their own workspace where all information is hidden for the rest of participants. The second one is collective. Learners interact and work on collaborative devices. The central objective here is to create collective knowledge (resulting from the group activitity). This clear separation between personal and collaborative workspaces led to many work in the CSCL and CSCW communities. Currently, people tend to set up highly complex scenarios, where learning activities in virtual and real locations take place alternatively. We mention here two projects where workspaces are used alternatively (the first one) or simultaneously (the second one).

In the Janus project (Loiseau et al, 2013), students perform a set of activities, swapping from personal to collaborative activities and from virtual to real worlds. This approach tends to reinforce the transfer rate of what has been learned in the game. In this context, Loiseau and their colleagues have developped a serious game in the archaeology domain which mixes virtual and real situations. During individual steps, the student must observe his/her environment with his/her tablet and take photos of places, objects, etc. Obtained information is only visible by him/her. Then, when s/he joins a group, s/he shares with others what s/he discovered, in order to classify all data collected by the group. In fact, information is produced before collaborative activities and modified (refined) during the collaborative step. The user can reuse his/her information later.

Students can also create information during collaborative activities. In the Caretta project (Sugimoto et al, 2004), they have to build a city in a collaborative way, and taking environment issues into account. They are around the board game and decide mutually where to put houses, factories and trees. In parallel, each student has his/her own pad. The common environment is reproduced on each device and students can realize the same actions. This allows them to visualise their actions consequences on the city state. All predictions are individual and if their results are appropriate, actions can be proposed to the group. Information is thus produced at same time than collaborative activities. The user can reuse his information immediately.

2.2 New technology supporting collaborative activities

The generalisation of mobile devices enabled new usage for work. Before, people generally used their own computer to realize personal tasks. Progressively, activities have been deported on new devices, smaller and lighter. Their size and their weight allow bringing them everywhere. As we saw in the previous part, we need personal and collective workspaces to realize collaborative activities. Personal activities can be supported on personal devices that can be combined with tabletops for collaborative activities.

The environment used by users in a collaborative activity tend therefore to be a multi device environment. This raises the problem of exchanging the right information between devices. To transfer information from a device to another one, we based our approach according to two research trends. Seyed and colleagues (2012) explain main gestures on tabletops and on tablets. They classify gestures which are natural to realize specific actions in a multi-display environment. They analyse interactions between collaborative devices (tabletop, digital board, etc.) and personal devices (tablets, mobile phone, etc.). For example, MacKenzie (2012) describes a platform where several users can simultaneously show their computer desktops on the same large screen, like a presentation of several devices used at the same time. This article thus proposes to display personal workspaces to only one shared workspace.

2.3 Territoriality notion

Scott and colleagues (2004) explain the territoriality notion on collaborative devices used by several actors placed all around the equipment. They based their study on the analysis of interactions between participants around a table and the observation of which workspaces become naturally unavailable. Users are intended to collaborate in order to realize a particular activity. The study concludes that the table is divided in three different territories dedicated to three different goals: personal activity, group activity and storage. First, personal territory is close to the user. All items concentrated in this area are considered private and belonged to him. Second, group territory is situated at the centre of the table. Everyone has the same distance to get access of items disposed there. Third, storage territory is on the periphery of personal territory. Items are reserved by a user but can be reused by another.

Multi device environments raise new problems, such as the identification of which user are doing an action on a collaborative pace. Scott (2014) article gives some tips to transfer information between tabletop and tablet. They propose a bridge between these devices. A personal area on the tabletop allows the user to move on information s/he wants and get it on his/her tablet. Conversely, when s/he pushes information from his/her tablet, it appears on his/her personal area and everyone can see it. For example, Antle et al (2011) realized a serious game on a tabletop where three players have to regulate village growth by preserving environment. They applied territoriality notion by defining each private workspace on the side of the tabletop and shared workspace in the centre. Players have an impact on the environment by using their own items and moving them into the middle of the game.

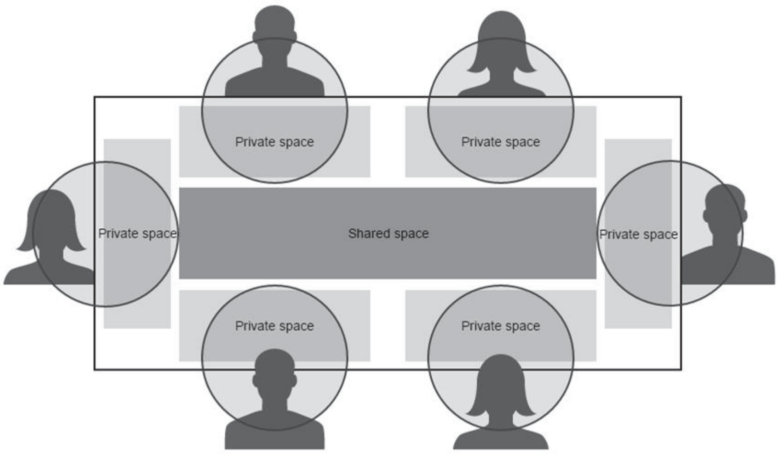

Figure 1: Territoriality notion on collaborative device

3. Environment design

We saw in section 2 how private and shared workspaces are central needs to realize collaborative activities. In this section, we aim at defining how to extend the territoriality notion in a particular multi-device environment. In order to understand better the relevant items to address for this research issue, let's consider an example of "classical" collaborative activities. A member of the group often organises his/her own pieces of information resulting from personal activities. S/he can then propose these results to the rest of the group (possibly only a part of them), work on the group ideas with the other members and can retrieve some information issued from the collaborative process.

In this example, each member of a group involved in the collaborative activity therefore needs to have support for making both collaborative and individual activities. This raises three kinds of constraints to face our research problem. First, we need a place supporting individual workspace and another one for the collaborative workspace. We need to define how to represent such workspaces through a device, a set of devices, or specific areas on a device? Second, we need to define the interaction protocol to move information between private and shared workspaces. Third, we would like to have partial views on pieces of information (to hide personal private parts of the information).

3.1 Adjacency map

In a collaborative activity taking place on a tabletop, we usually allocate specific tabletop areas for each individual workspace (Scott, 2004). In this approach, people are forced to perform individual tasks in this workspace, even if these tasks have no interest for the other members of the group. Taking advantage of multi-device environments allows us to propose an extension of this individual workspace (Figure 2). We propose to distribute personal workspaces between two specific areas: one area on a personal device (e.g. a tablet or a mobile phone) for individual tasks and one on the tabletop for the part of the collaborative process. The objects owned by a user need also to be seen (and may be taken) by other members of the group.

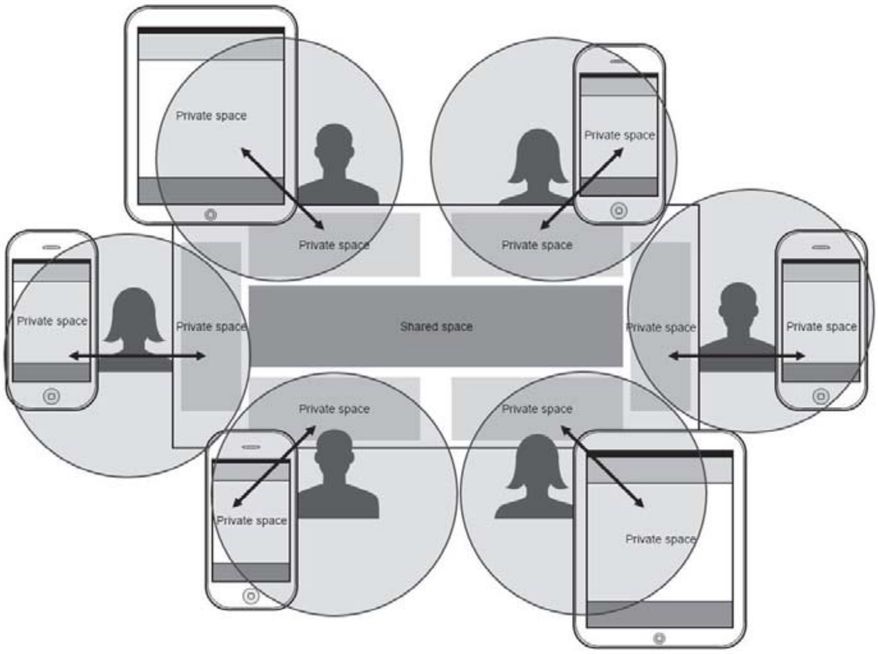

Figure 2: Extension of the territoriality notion by connecting personal devices to existing collaborative device

Private workspaces are therefore areas which are reserved for each user. We discern two kinds of private workspaces. The first ones are on personal devices (e.g. smartphone or tablet). All information on it is only visible by its owner. The second one is on collaborative devices. This area allows the user to take an object from the shared workspace in order to move it on his/her tablet. It is a bridge between personal and collaborative devices.

3.2 Defined actions

The design activity for multi-displays environments implies to select natural and intuitive interactions since users have to focus on their specific activities, dealing already with several devices, completing complex tasks with several other people, etc. Different studies, summarized in Seyed (2012), have pointed out that some gestures are particularly well adapted to transfer information between devices. We base our approach on these studies, and we propose different interactions according to the workspace, the device and the tasks (Table 1). We distinguish three situations: within the collaborative workspace, from collaborative workspace to personal workspace and the other way round.

3.2.1 From personal to collaborative workspaces

To move information from personal devices to the tabletop, "swipe up" interactions seem well adapted. For easy understanding, as a participant cannot keep a focus on anything, anywhere, at any time, this information should appear close to his/her private workspace on the tabletop.

3.2.2 Collaborative workspace

On tabletops, our interest is to enhance collaboration in the group. It means improving communication between participants. We offer attractive multi-touch properties of the device to make the different members of the group interact more. We propose to reapply basic gestures like “single tap”, “multi-tap”, “swipe”, “rotate” and “pinch”. Learners know how to use them and they will not be bothered in front of the tabletop.

3.2.3 From collaborative to personal workspaces

In order to transfer information from tabletop to tablet, we recommend using gestures like “swipe down”. The user puts his/her finger on the wanted area and brings it to his/her private workspace. We prefer to use a bridge for transferring information since we need to know which user is performing the action (regarding tracability issues). Furthermore, a summary of the information remains visible on the bridge. Participants can therefore remember who possesses a particular information, which is of course very useful for awareness.

Table 1: Abstract of all actions according to the device and the workspace for a collaborative activity

Action	Kind of activity	Source device (workspace)	Target device (workspace)
Create information	Individual Collective	Personal (private) Collaborative (shared)	Personal (private) Collaborative (shared)
Retrieve information	Individual	Collaborative (private)	Personal (private)
Move information	Collective	Collaborative (shared)	Collaborative (shared)
Share information	Individual	Personal (private)	Collaborative (shared)

3.3 Information visibility

This part concerns the information visualisation. What does the user see on his/her tablet? What does s/he see on the tabletop? The visualization of the same data according to the devices may be different, since the users, even in a collaborative activity, may want to keep some pieces of information hidden to the others. We define how information is displayed according to the device.

3.3.1 Personal workspace

On a personal device (e.g. on a tablet), the use is personal. Information on this device is exclusively dedicated to the user. Other members of the group should not get access to it. Anyway, for collaborative activities, user is free to share information by showing directly the tablet content to his/her group. We think that the user will not do it, especially because s/he likes controlling what other members are able to see[1]. S/he prefers keeping his/her own information for him/herself, choosing what s/he wants to share and using interaction between tablet and tabletop. Information visibility on tablet will generally be exhaustive. A user has access to everything and can control what s/he wants to share.

3.3.2 Collaborative workspace

On tabletops, the use is different. Each member of the group can see information and interact with it. As we previously observe, different workspaces compose the area of tabletop. The display is also different according the workspace. In the collective workspace, users can choose to share their information with the group. Information has therefore to be a fully visible. This allows each member to interact on available information. They can move, zoom in, zoom out, rotate and even bring information to his/her private workspace. Linked to any information, the initial owner must be visible in some way as well as the modifiers. We recommend this as an awareness hint enhancing collaboration.

3.3.3 Private workspaces

The parts of the private workspaces located on tabletop, are displayed differently. We are at the edge between personal and collaborative devices. Each member can see the user moving information to his/her private workspace, but it’s important it does not disappear from the tabletop area. It should stay in the private workspace with less details. It is part of the design activity to precise exactly what the “public” information will be. For example, in case of a shared text, we can chose to show only the first words of the text, while for an

[1] *Note written once the experiment has been performed: In some configuration, it seems that learners show directly the contents on their tablet…*

article, we can decide to exhibit the title. Users can modify information later on their personal devices, but no such modifications will be shown to the other members.

4. Case study

In this section, we describe an example of how to apply our proposition when designing a collaborative learning activity. This part first explains the scenario of the activity and how the design method has been applied.

4.1 Context

The case study will be carried out with first year students at the Institute of Technology in Chambéry (France). The scenario has been co-designed with teachers with the objective of reinforcing the "French grammar" level of their students. There are four classes of fourteen students, a teacher and three human observers. Students play a role game where they have several journalist tasks to perform. Their objective is to be employed by a virtual newspaper office. To reach this goal, they follow a four-step scenario.

Each student starts the scenario alone. The teacher's goal in this first step is to evaluate individually the level of the learner. This part takes place in Learning Adventure (Marty et al, 2012). It is a GBL environment, where students, represented by their own avatar, follow a learning quest. In this particular scenario, they have to solve exercises individually (although the environment allows collaborative learning). This part is adaptive in the sense that explanation videos will be proposed to the learners, based on the mistakes that they make in the evaluation exercise. The idea here is to allow the learner to repeat several activities and to train him/herself to French Grammar.

Then, the class is split into two groups (homogeneous level). When students finish their first activity, the teacher indicates them their team (according to their score in the previous activity). This step contains collaborative tasks. It is divided into two subparts. The goal of the first one is to create short texts (also called "brèves"[2] in the journalistic French dialect) describing news in relation with the university life. We apply our territoriality extension to this subpart, and we detail it later in the paper. For the second one, students have to illustrate the articles they have created. A role is allocated to each member of the group. The illustration task is again a collaborative process with different complementary roles.

During the last step, each group presents their work. The committee distributes individual and collective points to determinate the best group according to their ideas and their production. The winner will be employed by the newspaper office.

4.2 Evaluation prospect

We have scheduled the experimentation phase in June 2015. Its main objective is to analyse if students improve learning of French grammar when they collaborate. Our study focuses on three aspects. First, we evaluate student working alone on individual exercises. Then, s/he participates in collaborative activities. We compare all results we get during these two phases to measure if the writing quality is improved when sharing information with others. Finally, we observe the group's behaviour (remarks, feedbacks, etc.) and its impact on each member.

4.3 Collaborative activity

We apply our proposition for designing the second step of the process previously described, when students have to create short articles in a collaborative way. In this activity, the learners are intended to perform individual actions (creation of articles), collaborative actions (merging articles from different users, evaluating other members' articles). They need to share personal information with others or to collect global objects (resulting from a collaborative activity) to work on them individually. In this part, we explain how we use each of the relevant aspects of our proposition for the case study.

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[2] *We will translate "brèves" by "articles"*

4.3.1 Adjacency map

The scheduled experimentation allows us to use collaborative tabletops (one for each group). Tablets are also available for each student. Tablets will support personal activities. Each user is represented by the first letter of his/her name and his/her colour, in order to identify them during the activities. On this device, students can create and edit articles. S/he can also give personal annotations depending on grammar quality with three different smileys (good, medium, bad). Each student's evaluation is only visible by him/herself. When the student is satisfied about one article, s/he can directly share it with the group.

Collaborative activities take place on the tabletop. The student has to choose an area which will represent his/her location. This is the area which represents the private workspace on the tabletop (see our proposition in section 3). It allows transferring information between tabletops and tablets. Different actions can be performed from his/her private workspace. S/he can move around the table. During collaborative activities, s/he can also evaluate the idea of an article, with two different kinds of annotation. S/he has five "like" tokens (blue thumbs) and five "dislike" tokens (red thumbs). These tokens are limited in order to oblige students to take care of their use.

In the shared workspace on the tabletop, collective actions are at the centre of the activity. Short articles can be moved and rotated. Each participant can see what others do. When all students agree to validate an article, it means that the idea is valid and the grammar is correct, they can vote to remove it from the tabletop and keep it for the next activity.

4.3.2 Defined actions

Many possible actions were mentioned previously. We now explain how the user can realize them (Table 2). In both devices, touch events were used. On tablets, the student gets the list of each short article s/he creates and s/he retrieves. A single "tap" on a article allows the student to edit it. But when s/he lets his finger longer on an article, s/he has to "swipe up" in order to send it to the tabletop. We keep classic actions for text fields and buttons.

On tabletop, in private workspaces, students can "like" or "dislike" the grammar of an article by "swiping" an annotation to it. They can "tap" when they want to move it to have another workspace. When students want to take an article on their tablet, they must "swipe down" it to their private workspace on the tabletop. In shared workspace, as said previously, articles can be moved and rotated. We keep classic gestures to realize these actions. In order to validate an article, students have to make a "double tap" on it and decide if they confirm or cancel their choice.

Table 2: Abstract of all actions in our case study

Action	Kind of activity	Application
Create information	Individual Collective	Create article on tablet Validate article on tabletop
Retrieve information	Individual	Transfer article from tablet to tabletop
Move information	Collective	Move / Rotate article on tabletop
Share information	Individual	Transfer article from tabletop to tablet

4.3.3 Information visibility

Information is displayed differently according to the device (Figure 3). An article has a title, a description and some annotations. On tablets, as the use is personal, students can get an access for all information and can edit it. It concerns both created and retrieved articles. On tabletops, we distinguish visualisation between shared and private workspaces. In the first one, articles are shown as on tablets. Students have to know which information can be relevant for him/her to retrieve it or to validate it. The second one contains articles that students have taken on their tablets. We chose to show only the article's title available in private workspaces on tabletops. This idea allows other students to know the location of articles already shared without showing any modifications.

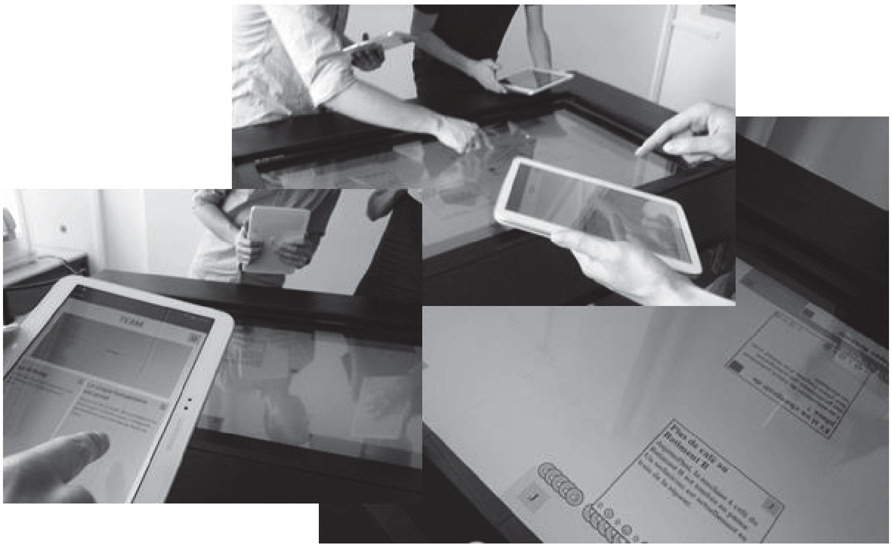

Figure 3: Illustration of collaborative activities on tablets and tabletop for our case study

5. Conclusion

In this article, we have presented an extension of the territoriality notion for collaborative activities in multi-devices environments. Tablets are used for personal tasks. Information on these devices is only visible by the owner. Tabletops are used for collaborative tasks. We defined two kinds of workspaces on the tabletop display. The first one is private. Each user has its own workspace in front of him. The second one, at the centre of the tabletop, is public and all users can interact with it. In our proposition, we have defined actions and information visualization for each workspace. We have applied this concept for designing a particular learning scenario for improving French grammar level. Experimentations have been (very) recently carried out. Although it is not the main subject of the paper, we wanted to indicate here that the collaboration activity has been particularly successful. We already extracted verbatim from students comments, such as “Usually I’m not keen on working in groups, but with this kind of collaboration support, I’ve changed my mind. I found it easier to express myself as a person inside the group”. In addition, the notion of extended territoriality has been extensively and easily used in the experiment. These first insights have to verified with a detailed analysis of video and questionnaires addressed to students.

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Learning and Motivational Processes When Students Design Curriculum-Based Digital Learning Games

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Abstract: This design-based research (DBR) project has developed an overall gamified learning design (big Game) to facilitate the learning process for adult students by inviting them to be their own learning designers through designing digital learning games (small games) in cross-disciplinary subject matters. The DBR project has investigated and experimented with which elements, methods, and processes are important when aiming at creating a cognitive complex (Anderson and Krathwohl, 2001) and motivating learning process within a reusable game-based learning design. This project took place in a co-design process with teachers and students. The learning approach was founded in problem-based learning (PBL) and constructionist pedagogical methodology, building on the thesis that there is a strong connection between designing and learning. The belief is that activities that involve making, building, or programming provide a rich context for learning, since the construction of artefacts, in this case learning games, enables reflection and new ways of thinking. The students learned from reflection and interaction with the tools alone as well as in collaboration with peers. After analysing the students' learning trajectories within this method of learning, this study describes seven areas of the iterative learning and game design process. The analysis also shows that the current learning design is constructed as a hierarchy supported through different roles as learning designers contained within one another. The study found that the students benefitted from this way of learning as a valid variation to more conventional teaching approaches, and teachers found that the students learned at least the same amount or more compared to traditional teaching processes. The students were able to think outside the box and experienced *hard fun* (Papert, 2002) - the phenomena that everyone likes challenging things to do, as long as they are the right things matched to the individual. They were motivated by hands-on work and succeeded in developing four very different and meaningful learning games and game concepts, which contributed to achieving their learning goals.

Keywords: students as learning game designers, learning game design, game design models, constructionism, pbl, students as learning designers

1. Introduction – a need for motivating learning processes

Motivation to learn decreases from the beginning of school age and becomes lowest upon entering the work force. In American elementary schools, 76% of students feel engaged, in middle school this figure falls to 61%, in high school 44%, and in workplaces worldwide as low as 13% of employees feel engaged in their jobs (Gallup, 2012; Gallup, 2013). Some researchers consider this a sign of a motivational crisis in the educational system (Sørensen et al., 2013). Since motivation to learn has an effect on students' ability to complete an education as well as on the quality of their results in school, this calls for new knowledge about increasing students' motivation to learn. The following is an example of how a student has trouble maintaining motivation:

> *People "die" really quickly . . . there are some teachers who are really good at involving us and there are others who are not – we also have that experience here in the class, where there are some lessons where we are just falling totally out, because the teachers are just too good to stand and talk a little by themselves. Then they just from time to time ask: Well what do you say? [Student changing tone of voice:] I don't really know, because you have talked for 2 hours, and I have not kept up [with what you are saying] half of the time because it was boring. (Interview with a student in the research project class concerning a lesson with little student activity.)*

You can bring a horse to water, but you cannot force it to drink. Similarly, you can seek to create a learning process for students, but you cannot force them to learn. So since the ability to facilitate the learning process is at the core of every teacher's duty, motivation becomes central as well. Motivation is thus part of every teacher's responsibility when creating activities and facilitating learning, but the will to learn is also something that students can be educated to choose and take responsibility for (Illeris, 2007; Bruner, 1966). The interest, will, and desire to learn are important parts of the learning process – a student's attention must be placed on *what is to be learned*, otherwise what they learn will be shallow at best. Motivation can also influence when individuals choose to learn, as well as what and how they learn. When people are motivated, they are more likely to undertake challenging activities and be actively engaged. Students who are motivated enjoy adopting a deep approach to learning and also tend to exhibit enhanced performance, persistence, and creativity (Schunk, 2012).

Consequently, motivation becomes an important part of the learning design and we have to develop conscious strategies for creating motivating learning situations.

Is it for instance possible to learn by using elements from games in our teaching approaches, using these elements to aid motivation in our education system? Fifty-nine percent of Americans play videogames, the average player is 31 years old, and half of the players are women (ESA, 2014). Seventy percent of teachers who use video games in their classes claim that the games increase students' motivation and engagement levels. This wide use of games – also among adults – invites continual investigation of how the use of games or game elements may open possibilities for merging motivational and engaging playful systems with traditional learning processes in formal education settings.

Many studies have supported the potential of using games in education as a means for learning (Gee, 2007; Barab, Gresalfi, and Ingram-Goble, 2010; Tobias and Fletcher, 2011). The use of games for learning is an active teaching approach, in which students are learning by doing, compared to a more traditional monologue form in which the teacher stands by a blackboard and talks about what is to be learned. Active teaching approaches can take on many shapes, and though evidence-based educational science is a difficult art (Biesta and Burbules, 2003), there is a variety of evidence supporting the idea that students will experience the learning process at a high level of cognitive complexity (Anderson and Krathwohl, 2001, pp. 67–68) through active learning (Michael, 2006). In this experiment, the goal was to turn the use of learning games into an even more active approach. If, instead of simply playing games, students are supported in building learning experiences into games – designing the games themselves – this may empower them as learners, teach them problem-solving skills, and enable a deeper understanding of the subject matter. The goal of this experiment was to enable a cognitive complex, motivating, and conscious learning process by letting students build learning games for fellow-students. The hypothesis was that this process would require the students to become very familiar with the curriculum that would be taught through the games. The questions investigated were: 1) What elements, practices, and processes are essential when creating sustainable, innovative, and motivating learning designs for teachers and adult students? 2) How does the learning design contribute to enabling a motivating and deep learning process?

2. Methodology and research project

This study is focused on the creation of an innovative and engaging gamified learning design in order to create motivating learning processes for adult students. The project was the result of three iterations of an on-going experiment. The investigation was conducted as a design-based research (DBR) study, in which the teachers and students were co-designers in the development and testing process. The study used mixed methods to investigate how the learning game design experiments answered the research questions. The collected data included field notes, video and audio recordings of actions and dialogs, observations from the workshops, semi-structured interviews with the teachers after each workshop, semi-structured interviews with the students after the last workshop, informal meetings, evaluation documents written by the students, questionnaires, videos of students' games being discussed and play tested, and the games themselves. The analysis took place by coding the transcribed data with an informed grounded theory approach (Thornberg, 2012), carried out as both a concept-driven and data driven coding process. Concept-driven coding uses concepts from theories and previous empirical data to find themes in reviewed data, whereas data-driven coding involves reading the data and searching for new phenomena that were not previously known (Kvale, 2009).

The experiment took place at VUC Storstrøm, an adult learning centre in Denmark. VUC Storstrøm offers the Global Classroom (GC) concept — a hybrid synchronous virtual and campus-based videoconference concept — to students attending an upper-secondary general education program, which is a full-time education program that lasts two years. The aim of this flexible class is to break down the walls of the classroom and offer a learning environment that responds to the needs of young adult learners (20–30 years old) to complete an education while fitting it into family and work life. Although teachers can ask their students to attend in person on specific days, the teachers generally prepare their daily teaching without knowing how many students will be in class versus how many will attend online. The students have different academic levels and different reasons for attending adult education classes, as well as different life situations and experiences. Furthermore, many students (60%) who attend VUC have at least one other discontinued education program in their pasts. This often influences their motivation to learn (Pless and Hansen, 2010; Sørensen et al., 2013). Therefore, the teachers in upper secondary classes at VUC strive to create a motivating learning environment for their diverse student groups. Recent reports have found that adult students enjoy activities with playful elements and that these elements help engage and motivate the students (EVA, 2014).

2.1 Research design

James Paul Gee (2011), a literacy and learning game theorist, defined the terms of little "g" game and big "G" Game. These terms are used to distinguish between what happens inside small digital games and "outside" these digital games — in the big Game where interactions between the players/learners take place as they discuss and negotiate the content, intention, and meanings of the small games - learning during this process. In spring 2015, two teachers and 19 students from Global Classroom participated in an experiment in which the overall learning design was made into a big Game while students designed learning goals for specific subject matters – history and English as a second language – into small digital games. The learning goals were focused on the American Civil War, human rights, and the liberation of the slaves. The sources the students used, as well as the game dialog, were expected to be in English. Teachers initially participated in a workshop, were introduced to the overall learning design, and tried some of the learning game design methods. Before the student workshops started, the teachers briefly introduced students to the subject matter, showed a film about the subject area, and introduced a few texts. The teachers and students then participated in three five-hour workshops once a week for three weeks that involved creating learning game concepts, making paper prototypes, and building digital learning games (Scratch and RGB-Maker) in a gamified learning environment. The teachers led the learning process while the researcher primarily observed.

3. Learning design and game design approaches – theoretical foundation

Because the design of learning games is a complex process, this project used different frameworks to support the students' development of learning games. The Smiley Model (Figure 1) was used as a heuristic for building learning games, and the overall learning design model (Figure 2) illustrates the intention behind the gamified learning design for students. The term *learning design* describes how the teacher shapes social processes and creates conditions for learning as well as the phenomenon of the individual student constantly re-creating or re-designing information through his or her own meaning-creation processes (Selander and Kress, 2012, p. 2; Laurillard, 2012).

3.1 The Smiley Model

The Smiley Model (Figure 1) is a learning game design model for building engaging learning games (Weitze and Ørngreen, 2012). The model was used to inspire and scaffold gamified learning processes in the current learning design. The Smiley Model addresses how to design the learning process and how to implement learning elements into the game while also considering ways to make the game motivating and engaging. The Smiley Model uses a learning design framework that considers the following elements: designing for the students' prerequisites for learning, the setting or learning situation, the learning goals, content selection, creation of relevant learning processes, and evaluation processes. The six game elements that can be used to set the learning design into play are: game goals, action space or narrative, rules, choices, challenges, and feedback. Each of the game elements are intertwined.

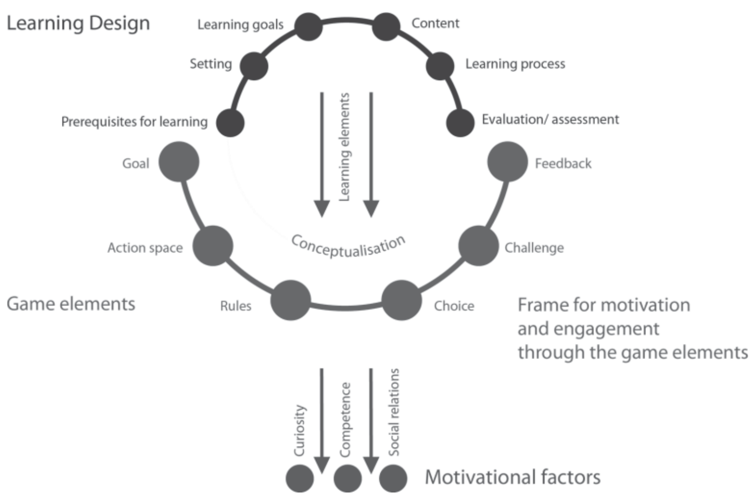

Figure 1: The Smiley Model (Weitze and Ørngreen, 2012)

The Smiley Model addresses the need to design the learning process, to set the learning elements into play through traditional game-elements, and to design for motivational factors. The three main underlying driving forces for our intrinsic motivation to learn are: 1) curiosity, 2) the feeling of achieving competence, and 3) reciprocity (Bruner 1966). These driving forces are further elaborated in Section 5.

3.2 The big Game and the small games

The goal for this experiment was to facilitate a motivating learning experience by making the whole *learning design* into a game. Inside this overall game, the students worked in teams and created digital learning games, while they embedded learning goals from the curriculum into each game (Figure 2) (Weitze, 2014a,b)

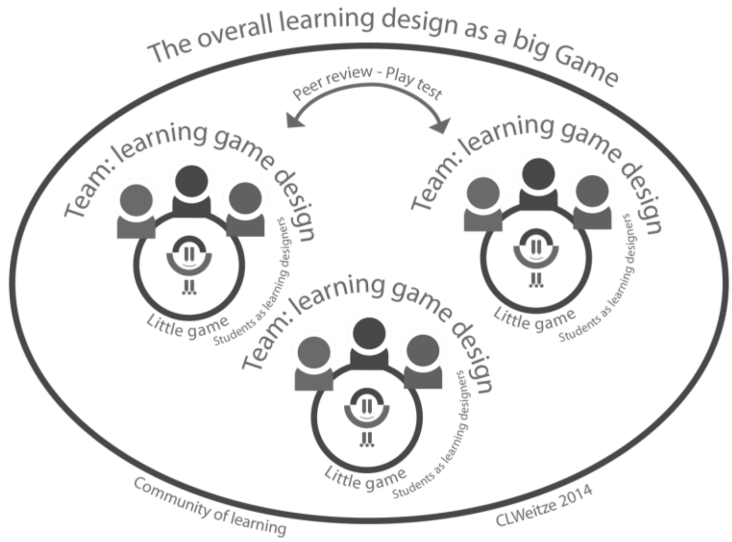

Figure 2: The gamified learning design

The big Game for this project was designed in 25 levels, encompassing tasks for building learning games; the framework was presented in a Google document for each of the teams. The Smiley Model inspired the learning design of both the big and the small games. In addition to the motivational purpose of gamifying the learning game design process, another goal was structuring and scaffolding the learning process to help novice students and teachers create the small games (Weitze, 2014a,b). Therefore, the aim of this learning project was that the students would discuss, negotiate, and finally master the intended learning goals while building and implementing these learning goals into their little games. In other words*: the student-game-designers were learning inside the big Game while designing the small games*. Another ambitious sub-goal was that students from other teams would be able to learn by playing different the small games and discussing game concepts, thus gaining knowledge, skills, and competence during this process.

4. Theoretical and grounded analysis of the empirical data

To analyse whether the gamified learning design process can facilitate motivating learning processes for students, the project used the Danish learning theorist Knud Illeris' theoretical framework for learning processes. Illeris (2007) argued that every learning process involves the following three dimensions: 1) the inner psychological process of acquisition (the content dimension), 2) the interpersonal interaction dimension, and 3) willingness and desire to learn (the incentive-driven dimension) (Illeris, 2007). The first two dimensions are important in teaching and learning because they involve the cognitive (content) learning and collaborative learning domains, emphasizing that both individual learning processes and social learning processes should be supported. However, the third motivational dimension is equally important in this case, since the target group in VUC's Global Classroom often possesses a weak motivation to learn. Therefore, the learning design has been focused on establishing individual, collaborative, and motivational learning processes for students.

The following sections will first analyse the students learning processes and trajectories in this project (4.1–4.4) and then analyse the motivating learning processes in the experiment (5–5.3). The purpose is twofold: to identify the facilitated learning and motivating processes taking place, and to find patterns that can be supported in future gamified teaching situations to enable motivational and deep learning processes for students.

4.1 Learning in the big Game

In the overall learning design – the big Game – the learning processes were facilitated by a problem-based learning approach (PBL). The students engaged in a learning process involving the development of a digital learning game. These small games then facilitated learning processes for their fellow students, by presenting and inviting interaction with game content that was relevant within the given learning goals. In order to find a solution to this problem and develop the project, teachers facilitated the learning process; the students were self-directed learners, and they dealt with problems as the driving force for inquiry corresponding to the principles of PBL (Savery, 2015). To assess what the students learned in this experiment, the project analysed what students and teachers said and did during pre- and post-experiment interviews and on-task activities. Furthermore, the main way the teachers evaluated students was through formative evaluative conversations and on-going discussions, as well as by asking each student to answer questions in Google docs about how well they understood the day's learning goals. This class is given an examination covering all subjects at the end of the year, and they do not have any formal marks before that day. Therefore, the students were generally very open concerning their understanding of the subjects, since the only purpose of the teachers' questions was to find out how they could support each student in the learning process. According to the teachers' analysis and evaluations of dialogues with the students, the conclusion was that the students learned the same amount or more, as compared with traditional lessons. Several students stated that the project required them to dive deep into the subject area, when building learning games, this resulted in memorable learning experiences.

4.2 Students as learning designers

One way to involve students in the learning process is to design learning processes in a way that enables the students to be self-directed learners. The process of students directing their own learning processes allows them to become their own learning designers. In order to activate the students as their own learning designers and also allow them to reach their learning goals, the process must be facilitated and guided by a teacher. In this experiment, the teachers were learning designers for the students, assisted by the game design assignments in the big Game. Additionally, the students were their own learning designers, both individually and in collaboration, as they discussed the subject matter, found content, and negotiated how to implement learning into the small digital games.

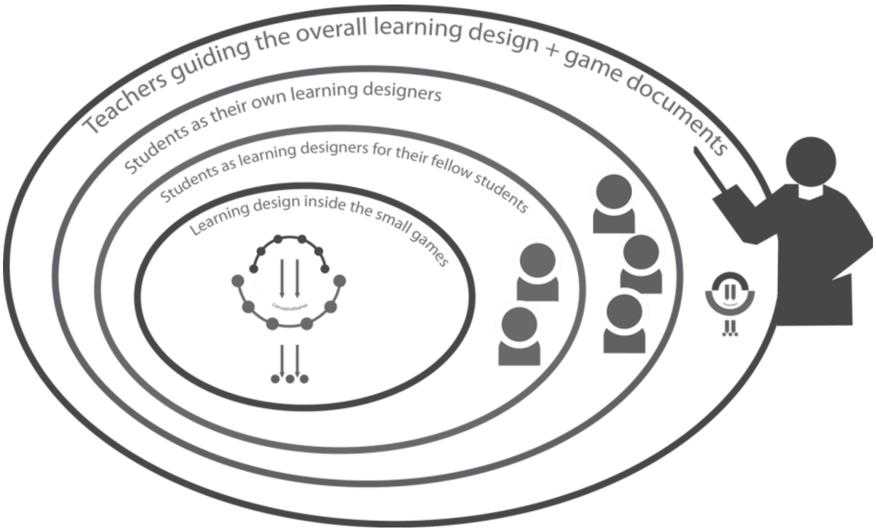

Figure 3: Learning designers in the game development process

The students planned ways to develop and implement relevant content into their own small learning games. By experiencing innovative learning processes, students developed knowledge about and an understanding of facilitating learning processes inside their prototype games. Students were empowered to choose the specific learning goals that players of their games should master as well as how these goals should be facilitated in their games. The students thus planned ways to facilitate both the learning process and the evaluative process inside their small games within specific subject matters. They also continuously discussed and evaluated their projects, aided by feedback from the teachers and playtests performed by their fellow students. Therefore, the students not only acted as their own learning designers and led their own learning process, but they also acted as learning designers for their fellow students – as they worked to facilitate learning activities and learning trajectories inside the small games. This process can be illustrated as different levels of responsibility for acting as learning designers and creating learning designs in a game development process (Figure 3).

4.3 The students learning trajectories when building the small games

This research project used grounded theoretical methods to investigate and differentiate between the learning processes that took place while students designed learning games. The analysis showed that while the students built the learning games, they went through an iterative process consisting of seven areas, in the learning-game design process, including conceptualising and building the games (Figure 4). These areas were not visited in a specific order, but rather arose when relevant. The students were self-directed learners as they chose how to solve the problem of developing a game, but they were scaffolded by the Smiley Model when solving tasks in the big Game. Therefore, the following learning trajectories also encompass elements from the Smiley Model.

Conceptualizing and building small learning games. The focus on the learning game prototypes and discussions about building these games was an important overall goal. The prototypes became materials for learning and enhanced the students' ability to conceptualize and create their learning ideas in the following ways:

- For individual students: The materials *talked back* (Schön, 1992), allowing students to become aware of gaps in their learning ideas or adaptions that may be required for specific learning situations and materials (Löwgren and Stolterman, 2007).
- For teams: The materials could be used in learning design and game design discussions between students, and between students and teachers. This is equivalent to a constructionism approach to learning through design, in which the construction of artefacts enables reflection and new ways of thinking, based on the tools students use alone as well as in collaboration with peers (Kafai and Resnick, 1996).

The students learning trajectories when conceptualizing and building small learning games were:

1) Studying and re-studying the learning goals and deciding their specific take on them. This process made the students conscious of what they were expected to learn. This topic was also continuously discussed with the teachers.
2) Researching reliable sources in textbooks and on the Internet. For example, texts, videos, and sources from the Library of Congress were used as reliable sources. One of the learning goals involved being able to determine whether the historical sources were valid; therefore, this was an important focus for the students as well. In this learning situation – making learning games – assessing the validity of sources became meaningful for the students, since they sought to create good learning games for their fellow students, ensuring that the learning experiences were relevant and authentic.
3) Content for story environment. Because the subject of the games was focused on history, students looked for relevant content to develop a story environment. This is an important part of developing a game equivalent to the narrative and action scene in the Smiley Model.
4) Matching storyline and learning situations in the game design. The students searched for relevant historical material that would make a coherent story and create a learning environment for characters inside the little game – specific learning situations inside the little game that would create learning possibilities for the player. This was also supported by the teachers' formative evaluations, which encouraged the creation of small communities of practice in the games to enable learning situations.
5) Systems thinking. One of the advantages of using games and game design as learning tools is the possibility to show cause and effect as well as providing multiple learning paths from which to choose (Meadows and Wright, 2008). These conditions will engage the player of the game, as he or she experiences the freedom to choose and learn from his or her own path (Bruner, 1966). As an example, one of the teams developed a game concept in which the player/learner could choose to be either Abraham Lincoln or Jefferson Davis in the American Civil War. The team conducted thorough research on how the different actions in the war resulted in different consequences. They debated heavily on how they could allow the player choose to see these consequences from the perspective of either the Northern or Southern states. After these conducting research and debates, the students mastered this aspect of the topic and were able to discuss it in great detail with their fellow students. Findings from the first iteration of this experiment (spring 2014) showed that it would enable higher levels of cognitive complexity in the learning process for students to develop learning games that were more complex than simple quiz games (Weitze, 2014a,b). This is due to the fact that quiz games often only require memorizing specific facts and therefore only achieve the remembering level of cognitive complexity

(Anderson and Krathwohl, 2001, pp. 67–68). The teachers also facilitated thinking in terms of cause and effect during the game design.

6) Designing specific game mechanics and facilitating learning and evaluation processes. The teachers encouraged students to facilitate both learning and evaluation processes in and around the small games. They also discussed how game mechanics – what the players/students could *DO* in the little game – were connected to specific learning goals that should be facilitated in the game. This resulted in many interesting and important findings that will be further described in a future article. As a single example, one of the teams created a story line inside the game and later invited the player to choose between different alternative solutions connected to the story. These alternatives or choices had different consequences, similar to the real life consequences that would have occurred at the time of the American Civil War. In this way, the players were educated by listening to the storyline and by the consequences of their own choices while playing the game. These game mechanics were also guided by the game elements in the Smiley Model: facilitation of goals, choices, challenges, rules, and feedback.

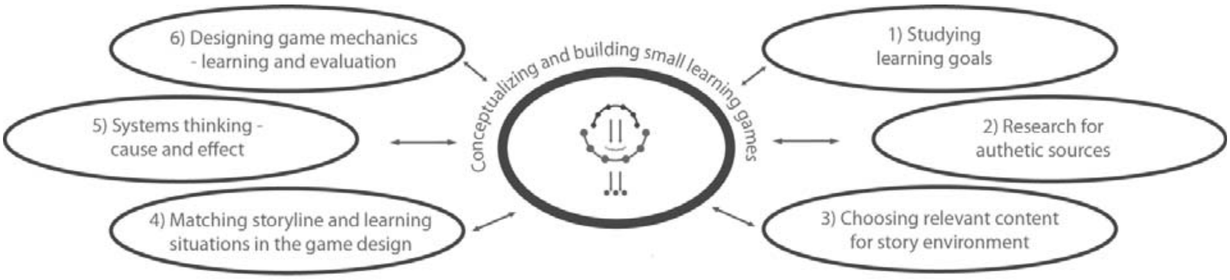

Figure 4: Learning trajectories when building small digital learning games

In summary, while teams worked through each of the previously mentioned learning trajectories, they reflected on and developed academic knowledge; more than one student stated that they would be able to remember details about the historical period they worked on for the rest of their lives. The concept of learning by doing – working through different learning trajectories while building games and being one's own learning designer – was successful for the students' learning processes both individually and collaboratively. The process offered a good alternative to *being told* about this historical period using a monologue-based pedagogical approach.

5. Motivation in the learning design

As stated in the introduction, motivation is an important part of learning. Jerome Bruner (1966), a noted educational psychologist, has a learning theorist approach to motivation. He believes that our intrinsic motivation to learn consists of three main underlying forces: 1) curiosity: the desire and freedom to explore things and the agency to decide for oneself – being in a playful and investigative mood; 2) achieving competence: the desire to show that we can do things and therefore are independent individuals; mastering a subject creates joy and pride and is motivating; and 3) reciprocity and relatedness: the desire to be an indispensable part of the community. People like to achieve goals with others, learning as part of a community of practice (Wenger, 1998). It is argued that if learning is planned in a way that enables students to achieve one or more of the three motives described above, students will be more likely to feel an inner motivation to learn (Bruner, 1966). Deci and Ryans' self-determination theory (2000) argued that in order to achieve inner motivation, you should be reinforced in autonomy, competence, and relatedness, and that these concepts are vital to cover essential psychological needs (Deci and Ryan, 2000). The three main keys to motivation described by Deci and Ryan strongly resemble Bruner's three driving forces.

In this VUC class, the teachers experienced problems creating social learning processes for their students. According to feedback from teachers, the students still had very few interactions with each other after five months – in class as well as during breaks. The students were quiet and reserved, and often only contributed minimally during the facilitated teamwork in class. Therefore, one of the goals of this study was to enable motivating social and collaborative learning processes. In the first workshop, the teachers agreed that they had not previously seen a similar level of active participation from their students. After the last workshop, one teacher stated, "…it has obviously been working miracles for the social environment in class. Almost everyone worked hard and … I think that many of the quiet students really brightened up in this period. We have previously faced a real struggle creating a good social atmosphere" [translation by author]. The teachers also reported that the new positive social learning habits still remained two months after the experiment. This raises a question regarding what part of the learning design caused these improvements in the social learning processes, which can be difficult to assess in the "messy setting" of a learning situation. However, when seeking to understand how a motivating learning situation arose, it is relevant to examine both the characteristics of the learners and the learning design. Seventy percent of the students in this class played games on a daily basis, which may have contributed to their positive attitude towards creating games in class. According to interviews and observations, the students were more motivated and engaged than normal. The teachers observed that almost everyone participated actively – generally only three or four students showed this level of participation. The teachers were also surprised that students worked for five hours in a row, choosing to neglect their breaks. This was considered a further sign of engagement in the learning process. Bruner's three motivational forces (1966) were used as lenses when analysing motivational processes in this project, as detailed below.

5.1 Facilitating curiosity

Curiosity is fundamental to learning – it is innate. Curiosity makes us investigate our surroundings in a playful way, looking for the borders of our knowledge and experiences. Curiosity also makes us challenge ourselves to go out into the unknown, where we are *novices* (Bruner, 1966; Illeris, 2007). Curiosity is part of the inner motivation to learn (Deci and Ryan, 2000). The adult students worked hard to create their learning games and were generally very engaged in the process. Even when they struggled with the concept of developing a learning game – a new endeavour for them – they carried on, often due to good advice and guidance from their encouraging teachers (Weitze, 2016). Papert (2002) coined an expression called *hard fun* that describes the phenomena that everyone enjoys having challenging things to do, as long as the challenges are properly matched to each individual, their developmental states, and the current culture. One goal of this iteration of the learning design project was establishing a feeling of *hard fun* in the digital game design phase, as well as in the conceptual development phase (Weitze, 2014a). The students experienced a level of hard fun when designing; they struggled with their assignments to design learning games, and they succeeded in creating four very different and meaningful games.

Figure 5: Prototypes – materials for learning

5.2 Creating the feeling of competence

Apart from small periods of uncertainty regarding their next steps, the students worked very diligently to create good learning games. They were enthusiastic when they explained the games that they were creating, and they thoroughly described the details and how they were trying to think outside the box to avoid simple quiz games (Weitze, 2014b). During the second and third workshops, the students expressed a feeling of pride for their games and a will to master the challenge of creating a learning game. The overall learning design process enabled them to gain many additional competences: gathering knowledge to meet learning goals, creating a storyline and English dialogues for characters in the games, building paper prototypes while discussing learning goals, and coding the digital games while implementing learning objects. According to the teachers, this new variety of tasks and the opportunity for hands-on work while developing the small learning games appealed to a group of students who had previously been quiet and inactive. The students developed detailed prototypes (Figure 5) that they used to discuss how learning should be implemented in the game. It was clear that the students enjoyed making these prototypes, and the teachers witnessed the emergence of new competencies among many of the students and also noted that they were generally more enthusiastic and willing to participate.

5.3 Making reciprocity and relatedness possible

One of the teachers' main goals for this experiment was to create a more engaging social environment for their adult students. This goal was achieved to a great extent, and the effect lasted after the workshops ended. The big Game was designed, so students were able to collaborate and compete in a friendly way on teams. There were many observations of engaging collaborative processes. These processes allowed the students to learn from each other and to create knowledge together: they read aloud for each other from the sources and discussed and negotiated what content to implement in the games and how to create historically realistic learning game experiences for their fellow students. The students explicitly expressed that they enjoyed working on their teams because their specific group had good teamwork. This teamwork could be readily observed as the ability to work together, solve problems, and discuss relevant matters. It was also evident in their ability to divide the workload in ways that acknowledged each group members' strengths – for example, being good at coding versus being good at writing dialogues. As mentioned earlier, the teachers expressed that it had previously been difficult to create a good sense of collaboration in the class. The big Game had explicit rules for gaining Social Experience points (SXP). To gain SXP, you could help other teams, ask the other teams for help, or make sure that everyone in the team participated equally on each level. This rule regarding SXP was stated from the start, and the students joked about it throughout the workshops. The existence of the SXP points system may have contributed to the students' enhanced attention towards creating a good working environment.

By using Bruner's (1966) three motivational forces as analytical tools, this study suggests that the students and teachers experienced many different motivational learning processes in this learning design; the analysis also indicates that the motivational learning processes were supported by the overall learning design – the big Game – and by building the small games. This is an important finding because creating a motivating learning process capable of supporting a cognitive complex learning process for the students was the primary aim of the study.

6. Conclusion

This study experimented with creating a reusable, innovative, and motivational learning design for adult student-game-designers, allowing them to *learn inside a big Game while designing small digital learning games* in cross-disciplinary subject matters. The findings have shown that this learning design contributed to a motivating and deep learning process for the students. This was facilitated by both individual and collaborative learning processes. Using learning game design – an activity with playful elements – as a learning method was engaging for this adult audience, who found the task both challenging and motivational. The learning approach was a combination of problem-based learning and constructionism and the students were implementing history and English as a second language into the games. The overall learning design used the Smiley Model as a framework for the big Game, to guide the learning and game design processes for the students and teachers. The findings showed that the central theme of the learning process was conceptualizing and building small learning games by building upon the following six areas in the iterative learning-game design process: 1) studying learning goals; 2) researching authentic and relevant sources; 3) choosing relevant content for the story environment; 4) matching content with a storyline and learning environment in game design; 5) systems thinking – looking for cause and effect relationships and providing multiple paths; and 6) designing game mechanics – learning and evaluation. During the analysis, it was determined that the following learning design processes were contained within one another: the teachers guided the overall learning design assisted by the game design document; the students acted as their own learning designers leading their own learning process, but were also learning designers for their fellow students. Finally, learning processes were facilitated inside the small games.

Because motivation is an important part of learning, it was an important finding that many of the quiet students became more actively involved – according to the teachers, this experimental learning process greatly improved the social environment in class and everyone was actively involved. When using Bruner's (1966) three motivational forces as analytic tools (curiosity, the feeling of achieving competence, and reciprocity-relatedness) the findings were: 1) the students experienced inner motivation and *hard fun* and succeeded in making four very different and meaningful learning games; 2) the students tried to think "outside the box" and expressed a feeling of pride for their games and a will to master the challenge of making a learning game. The learning design enabled the students to develop many kinds of competences and work actively hands on, which seemed to appeal to a new group of traditionally quiet students; 3) there were many observations of engaging collaborative processes that allowed the students to learn from each other and to create knowledge together. The increase in these social learning processes may have been supported by specific social rules in the big game.

This DBR project used mixed methods and informed grounded theory to investigate and analyse the students' level of motivation and engagement in their learning processes. The analysis found signs of learning and motivation among the students and in co-design processes developed knowledge about how to refine this learning design.

Though DBR takes place in the complex setting of a classroom, this iterative experiment has created knowledge about a problem area and made important contributions to the researchers' and the teachers' learning processes. Future goals include continuing the development of this new way of learning, to further refine it and to disseminate it to interested teachers and students.

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Traces: A Pervasive app for Changing Behavioural Patterns

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Abstract: The ability to travel long and short distances at any time enables a high degree of individual flexibility on the one hand, but it also results in a number of adverse effects, including massive impacts on traffic flow and a constantly growing lack of space. Increasing emission levels (CO_2, NO_2) and the associated fine dust pollution are to be considered serious barriers for meeting internationally agreed targets on environmental preservation; they will also negatively affect the health of city residents. As a result these factors will increase community and state expenditure (through accidents, parking tickets and so on) as a direct result of insufficient sustainable and future-oriented individual traffic behaviour. In course of the state funded project "Traces" we aim to tackle these challenges by promoting sustainable mobility in the urban area using a contextual gamification framework. During the past year behavioural theories have been combined with state-of-the-art ICT technologies in order to create an immersive playing experience. During the game players will be motivated to choose from a variety of inter- and multimodal mobility options. The gamification framework uses a pervasive gaming approach with location-based elements for changing behavioural patterns surrounding individual mobility choices. The main goal is to achieve a change in long established behavioural patterns, demonstrate feasible alternatives and establish an authentic gaming experience, creating an incentive to use inter- and multimodal mobility forms (persuasive design). Through the integration of modern ICT technologies target groups will be addressed in real life conditions. The bi-directional transfer between the virtual and real game world will be additionally enhanced by offline-campaigns in urban space (pervasive design). In order to achieve our objectives, the game concept as well as the mobile application demo will be developed within living laboratories (labs) in order to stay as close as possible to the end-users' needs. The basic game mechanics, functionality and usability of the game framework are optimized following an iterative design process. Additionally, experts will be involved in dedicated workshops for enabling a professional integration of best-practice experiences. The project results are constantly evaluated and will lead to an action plan for promoting and enhancing inter- and multimodal mobility as well as an impact analysis of the behavioural and cognitive effects.

Keywords: gamification, pervasive games, behaviour change, sustainable mobility

1. Introduction

Supporting multi- and intermodal mobility is a key strategy in transport policy to increase sustainable mobility. Studies confirm increasing inter- and multimodal behaviour especially in (sub-)urban areas (Streit et al., 2015). Ahrens (2012) states that approximately 50% of the population are using multimodal means of transport. Most frequently these people are single, young, well-educated and live in cities (Franke, 2004; Ruhren et al., 2005; Mühlhans, 2013). In general inter- and multimodality are available options for a traffic participant: in only 44% of all car trips, inter- and multimodal behaviour is actually prevented by constraints (Ahrens et al. 2010a). Activating this high potential leads to a reduction of the negative impacts of car traffic (e.g. noise, dust, CO_2 emissions and congestion). The growing trend in society towards sharing things (beds, cars, information) rather than owning them, has also increased demand for more flexible and pragmatic mobility services (e.g. car sharing, ride sharing, e-bike rental). Nevertheless, innovative mobility services currently exist only as niche solutions.

Over the past year we developed a mobile application in cooperation with the Austrian Research Promotion Agency. The aim is to promote multimodal modes of transport in urban environments using state of the art ICT in combination with an integrative game framework. We decided to use elements from pervasive games (treasure hunts), serious games (narration) and gamification (incentive system). As a theoretical basis we defined a synthesis between the self-regulation model (Bamberg, 2012) with behavioural and motivational theories. The goal of our app is to achieve a change in behavioural patterns of our users regarding their mobility choices. The use of gamification strategies in the context of traffic management seems highly plausible because of the ability of games to foster intrinsic motivation. Gamification is not about creating games, it is about using the well-proven incentive system of digital games like points, badges or levels to motivate users for certain activities or actions. Next to the entertainment factor, more serious concepts enrich the design. The app features interesting quizzes which relate to the home city of our app, Vienna. Last but not least, behavioural triggers in the form of offline quests and events play a major role in our game concept.

The goal is to motivate participants to break up their rigid mobility behaviour and to use more sustainable alternatives like car sharing, public transport, skateboarding, cycling and walking. This is a very soft measure, aimed at reducing reservations and prejudices against sustainable alternatives, and at taking a first practical step towards more flexible mobility behaviour. Different studies on the impact of mobility management (e.g. Cairns, et al. 2008; Gärling et al., 2009; Brög et al., 2009; Richter, Friman and Gärling, 2009 and 2010) affirm the positive effects of soft measures on the mobility behaviour of traffic participants. Fujii and Taniguchi (2006), for instance, show an increase of 50% in use of public transport simply by informing people of the negative aspects of car driving and giving positive feedback.

In the field of mobility management, especially when changing mobility behaviour is the goal, a gamification approach is not widespread. Furthermore there have been few connections made between behaviour change models and specific motivational models which can be applied in the context of game design. A synthesis of gamification elements (e.g. collecting points, getting achievements, levelling up, experiencing an immersive story) and empirically proven behavioural models (e.g. theory of planed behaviour, norm-activity theory, self-regulation theory) could be a fruitful approach for a controlled and voluntary change of mobility behaviour.

2. Theoretical framework

This paper focuses on a playful and willing change in mobility behaviour. The theoretical framework is based on stage-based approaches, such as the transtheoretical model (Prochaska & DiClemente, 2005) and the derived self-regulation model from Bamberg (2012). In a further step, findings of motivational approaches will be integrated in this modified model.

2.1 Self-regulation model

Mobility management deals with the question, how the behaviour of people can be changed through measures or interventions. In general, traffic participants should organize their daily activities (e.g. work, education, shopping) in an efficient manner in terms of low cost, energy saving and environmental protection. To achieve these objectives, a wide range of different interventions are used. Some studies investigated examples which effect mobility behaviour positively by sharing information and practical knowledge (Staats, Harland & Wilke 2004); by the specifications of goals (Locke & Latham, 2002); by comparison and competition with other players; or by rewards and punishments via feedback (Fujii et al., 2009; Taniguchi & Fujii, 2007; Cairns et al., 2008; Froehlich, 2011). However, many of these “soft” interventions are insufficiently embedded in a comprehensive behavioural theoretical concept to be able to evaluate their effectiveness.

In order to change human behaviour, it is necessary to understand the underlying behavioural processes. Many theories of motivational psychology and behavioural science, like the theory of planned behaviour (Ajzen & Fishbein, 1975 & 1980), the norm-activation theory (Schwartz, 1977) and the self-regulation theory (Bamberg, 2012) try to describe, explain and understand mobility behaviour. In line with Prochaska and DiClemente (1982), the self-regulation model from Bamberg (2012) claims that behaviour changes through a time-ordered sequence of stages. Each stage involves various cognitive and motivational difficulties occurring throughout the process of behaviour change. Bamberg (2010: 231ff) describes the following qualitatively different stages:

- Precontemplation: In the first stage individuals have to be aware of their own behaviour. By self-focusing their behaviour, they have to choose a binding goal amongst competing wishes (=goal setting). They consider the feasibility and desirability of relevant outcomes. Before choosing a valued goal (=goal intention) the subjective probability of achieving it is evaluated.
- Contemplation: In this stage individuals consider the pros and cons of different options and choose the most suitable means for reaching the goal.
- Preparation/Test: Individuals form a concrete plan of when, where and how they can implement the intention for a new behaviour. The first practical steps will be taken.

- Maintenance: In the final stage individuals have a new behavioural pattern. Since the new habit has substantial benefits, relapse into the old behaviour can likely be avoided.

For our investigation we simplified the self-regulation model as shown below. We focus on the transitional points (goal intention, behavioural intention, implantation intention and new habit) between the different stages. Depending on the specific mobility behaviour, a player belongs to one of these four stages. At each stage different cognitive and motivational constraints are present, which can prevent multimodal and sustainable mobility. As in the self-regulation model we implement special interventions in the form of quests to overcome these barriers (see figure 1).

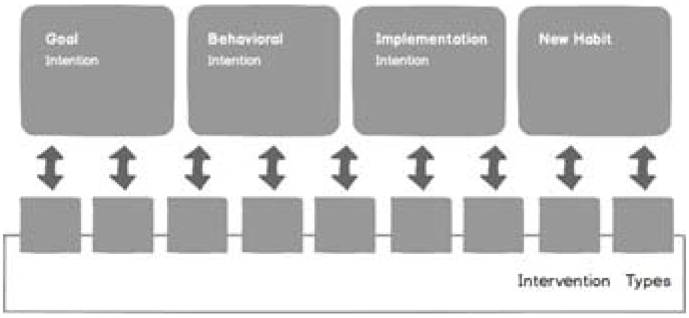

Figure 1: Modified self-regulation model (Bamberg, 2012)

2.2 Model synthesis

The motivational impact of digital games has been analysed in numerous studies (Anetta, 2008, 2010; Ryan et al., 2006; Wernbacher, 2012). What secret lies behind the apparently strong link between motivation and digital games? To answer this question we have to go back in history and start with early behavioural theories. Atkinson (1957) defined the need for achievement as a relationship between the perceived level of difficulty and the appeal of success of a certain task. The author predicts that individuals with a high fear of failure and low need for achievement may raise their level of effort following failure and lower it after success. For the first phase of the self-regulation model, an ideal interactive environment therefore consists of tasks of middling complexity, which are rather challenging but not impossible to solve for users. Skinner (1938) established the principle of operant conditioning. This theory describes the positive reinforcement of desired actions following the formula: correct answer = imminent reward. This stimulus-response cycle, also known as the "Skinner Box", is applied broadly in educational contexts. Each desired behaviour is reinforced, while each unwanted behaviour is punished. While the focus of the synthesis is not on negative reinforcement, the idea of reliable feedback is of particular importance for the incentive system of our gamification framework. The Fogg model (Fogg, 2009) basically utilizes these elements and combines them in a model which correlates the perceived level of complexity with triggers that lead to high levels of motivation.

The behavioural intention stage is about the creation of an incentive system which offers a broad range of rewards while also satisfying social playing motives. Csíkszentmihály (1990) defines “Flow” as perfect interplay between the complexity of an action and the abilities of the person trying to succeed at the action. While the idea is to create a balance between action and outcome, the focus is not on extrinsic feedback but on tasks which are motivating on their own. The “Zone of Proximal Development” (ZPD) puts the emphasis on social support which is crucial for empowering players to progress through the four phases of the self-regulation model. According to Vygotsky (1978), play creates a broad ZPD, both in cognitive and socio-emotional development.

In the implementation stage the focus is on potential effects triggered by one’s actions. Bandura (1977) defined self-efficacy as one’s belief in the ability to succeed in specific situations. The ability and motivation to pursue certain goals depends on level of mastery, emotional state and social feedback. Weiner’s (1994) “locus of control” theory offers a detailed insight into different levels of attribution which directly influence the interpretation of external effects. The model differentiates between internal and external causes for success, those which are stable or unstable, and those which can or cannot be controlled. The ideal combination involves internal attribution processes (“I was successful because of my effort and my abilities”), which are both stable (“this will always be the case”) and controllable (“I am able to repeat my success”).

In the final stage the focus is on maintaining and reinforcing the new habit. In this context intrinsic motivational processes play a major role. Intrinsic motivation can be regarded as a prerequisite for deep learning processes and behavioural change. Perceived autonomy, competence and relatedness are key factors in this process. (Przybylski et al., 2010).

Now we leave the theoretical level and take a look at the synthesis on a more practical level (see figure 2):

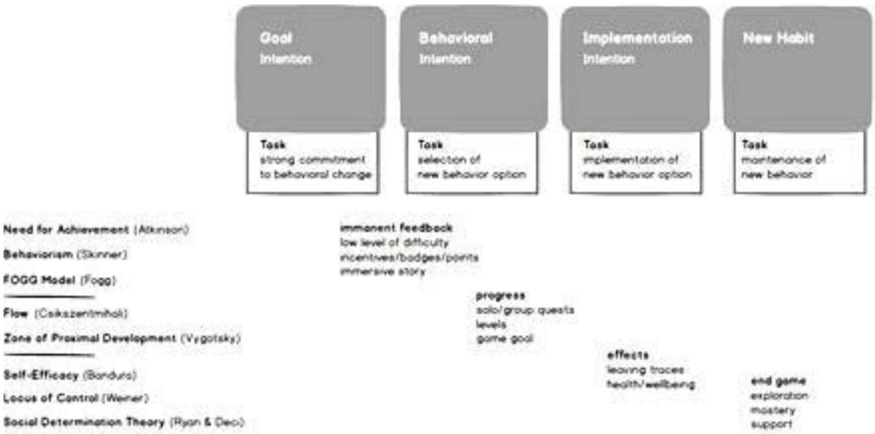

Figure 2: Practical level of model synthesis

In course of the goal intention stage extrinsic rewards (badges, points, incentives) are constantly triggered. The app is easily accessible, with a focus on a low threshold for entry to the game. Pervasive game elements are placed prominently all over the city, while the story will be narrated by actors at offline events.

During the next stage the player is presented with a stream of quests. There are different types, including “geolocation quests” and “quiz quests. The quest system reacts to choices made by the player and depends on his/her mobility behaviour. The choice of sustainable modes of transport as well as multimodal mobility behaviour is rewarded with (more) points and level upgrades, while monomodal mobility behaviour (especially car driving) inhibits the game progress. The game's ultimate goal (leaving colourful traces and making Vienna a more beautiful city to live in) can be achieved alone or together, while working together is crucial for success in the game itself.

When reaching the implementation stage the effects on the virtual and real world are displayed vividly, showing each trace as a collection of colourful dots. We also expect to enhance the players' feelings of wellbeing and physical fitness if they choose to commute by bike or decide to explore the city on foot.

The final stage will be all about providing an open and social playing experience. As the shared game goal is now within reach, players are motivated to explore the entire city, to discover every NFC Tag and to visit every event from the offline campaign. Towards the end of the game high-level veterans can strive for even more points, but are also encouraged to support less experienced players in their daily mobility choices. The storyline reaches the end of its arc while possible sequels to it are handed over to the community.

3. The app

3.1 Gameplay

Since the motivational framework is based on a modified form of self-regulation, which assumes different behavioural stages, at the beginning we had to know what the mobility behavioural profile of a player would look like. To work this out, our players are asked to choose from five defined mobility types, which represent their actual mobility choices. For characterisation of the respective mobility type two aspects are important, mode choice and the potential for changing behaviour. Depending on the mobility profile of the player he or she is assigned to a stage of the self-regulation model. The more flexible (=multimodal) and sustainable the player's mobility behaviour, the higher the stage assigned. For example: a player who only drives by car and does not want to change his mobility behaviour represents the first stage of the model (=goal intention). In this stage the quests focus on awareness raising and self-reflection using quizzes and easy quests like “Get your bike nice and clean”.

In this manner quests are developed for all four stages of mobility behaviour (as displayed in figure 3). The aim of these quests is to motivate players to do things voluntarily and regularly. The great advantage of this stage-based triggering is that the interventions can be tailored to the individual mobility profile of the player. Quests should help players to complete stage-specific tasks to reach the next stage (car user, flexible user, public transport user and finally cyclist), which ultimately leads to flexible and sustainably mobility choices.

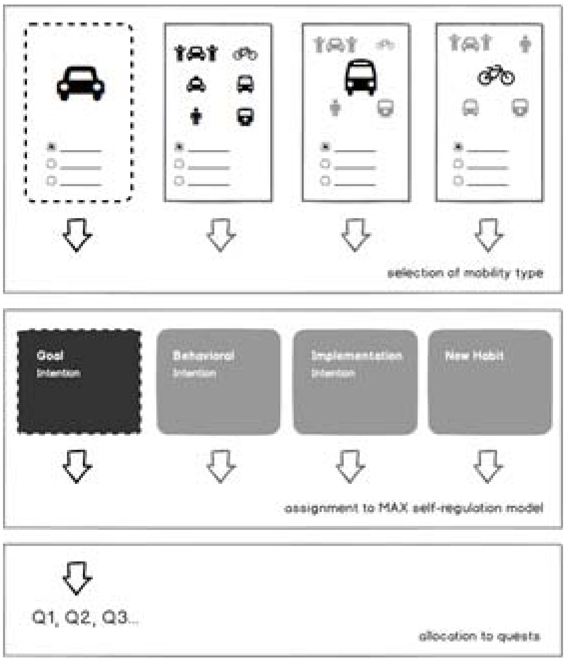

Figure 3: Gameplay concept, Q=quest

The core game mechanic relies on leaving traces: Each player has a number of color buckets that can be filled up by taking a certain mode of transport. To start with each bucket is empty and has to be filled. More distance and more multimodal mobility choices equal more color. Trams are yellow, bikes green, metro orange, etc. If the color bucket is full enough the player can color his or her tracks, which eventually appear on the map of Vienna. A beautiful colorful map shows who takes what mode of transport at which time, while the tracks of all players are shown together. In this way it is very easy to track and map happiness in Vienna as a bright visual effect as displayed in figure 4.

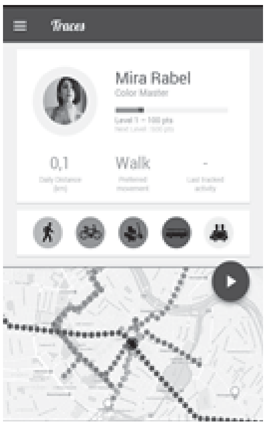

Figure 4: Personal profile

As well as leaving colourful dots, the app features quests to encourage players to explore the city, try different means of transport and to learn more about the consequences of mobility choices. Players can score points by unlocking locations, solving quizzes (as shown in figure 5), travelling a certain stretch or discovering 'hidden gem' points-of-interest. In the course of group quests, team challenges are triggered which encourage players to take different types of transport on the same day.

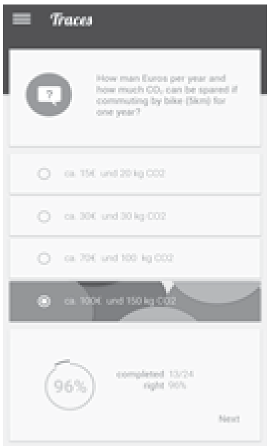

Figure 5: Quiz quest

We utilized a design philosophy that allows players a certain leeway for expressing themselves, but without assuming universal emotional responses to experiences. We identified five personas to represent the relevant types of mobility for different players' mobility behaviours, motivations, and belief-systems in order to help us understand the user and anticipate his or her interaction with the app, as well as to develop the quests and narrative elements throughout the game. Play-personas as design tools represent an expectation of how players would like to craft their experience.

Figure 6: Personas as game characters (a, b, c, d, e)

Personas are detailed composite user archetypes who serve as main characters in narrative, scenario-based descriptions that iteratively inform the design of a product, so that features emerge directly from the goals. Typically a persona is a description of behaviour patterns, goals, skills, attitudes, and environment, with a few fictional personal details to make it a realistic character. 6a – Maximiliane is a young student and heavy user of multimodal non-car mobility (aim: keep users like her motivated to maintain behaviour); 6b – Judith is a middle-age mother and entrepreneur and mainly uses public transport (aim: make her a role-model for users that also care about their ecological footprint); 6c – Marilen is a young manager, and flexible in her mobility choice (aim: make users like her aware of sustainable lifestyles, and change their convenience-based attitudes); 6d – Franz is a car-addict, mainly influenced by old habits and a lack of infrastructure to use public transport (aim: change his attitude and activity); 6e – Camillo is a petrolhead (aim: show users like him the value of alternative mobility means).

3.2 Offline campaign

Next to the integration of pervasive elements the game concept also involves offline interventions which focus on analogue representations of the core game goal: making Vienna a more colourful city. Our project involves digital technologies, which are accompanied by an unusual ambient media campaign in order to help to engage citizens with their living environment, their transport choices and ultimately with each other.

In designing the offline campaign around the app, we aimed for a proper balance between the intrinsic pleasure of playing and the satisfaction reaching a goal outside of the game itself (i.e. long-term behaviour change in the choice of inter- and multimodal mobility). This involves colorful interventions placed throughout Vienna, along frequented traffic junctions, near landmarks and buzzing locations, such as cafes, restaurants and shops. The interventions have a unique look and feel and convey the overall creative and recognizable identity of the game. Since the app uses points as main design element, the offline campaign also uses circles, colorful spots and balls as visual element in order to create a sense of continuity (see figure 7).

Figure 7: Example of offline intervention

The game itself is pleasurable to play and acts as a catalyst for potential follow-up actions on complex issues such as the future of urban mobility. The unique feature of our app is that it is played in the virtual world but acted out in the real world, and only if the real-world experience leaves an impression that's relevant and enjoyable for the users will they engage, and change their behaviour. This connection is enhanced using state of the art technologies like NFC (near-field communication) and AR (augmented reality) markers which are placed at relevant places. These markers can be scanned by players using a smartphone in order to unlock special incentives, to receive background information or to trigger quizzes.

4. Impact

4.1 Impact of digital games

Far beyond their obvious success as entertainment media, digital games have increasingly gained attention as facilitators of motivation and learning processes. The potential benefits of digital game-based learning (GBL) applications and strategies have been explored thoroughly (Annetta, 2007, 2010; Bers, 2010), as have their limitations (Wagner, 2009; Linderoth, 2010). Various initiatives are promoting educational gaming as a suitable tool to face the challenges of the digital age. The scope and variety of game-based learning initiatives make it obvious that the potential of digital games is increasingly acknowledged within the educational community and outside it, and that the application of this potential in educational practice is an openly declared goal. Prensky (2012) states that today's students grow up as digital natives who natively use digital media from early childhood. This hypotheses seems highly plausible when looking at the current economic and social reach of digital games: in 2012 the game industry grossed about 13 billion dollars – replacing Hollywood as the world's leading entertainment industry. 510 million people currently play games on social media platforms, 14% for at least an hour a day. Just in the EU and USA players invested more than 2 billion hours of playing time into the top-ranking games "Minecraft", "World of Warcraft" and "League of Legends". According to a study by Gartner (2012) 50% of companies involved in innovation management will use gamification strategies by 2015.

The impact of digital games on cognitive, motivational, behavioural, social and affective outcomes has been examined in various studies (see table 1).

Table 1: Studies on the impact of digital games

source	effect	direction	significance
Green & Bavelier (2007)	spatial resolution	positive	p<.001
Tüzün et al (2009)	intrinsic motivation		p=.02
Gentile et al. (2009)	prosocial behaviour		p<.001
Durkin & Barber (2002)	self-concept		p<.01
Ferguson & Garca (2010)	cooperation		p=.02
Rosser et al. (2010)	motoric abilities		p<.001
Mhurchu et al. (2012)	physical activity		p=.04
Gee (2007)	problem solving skills		N/A
Gebel (2006)	media competence		N/A
Wernbacher et al. (2012)	knowledge, motivation		p<.05

4.2 Expected impact

Since the emphasis is on fostering intrinsic motivation, self-concept, cooperation, physical activity and knowledge transfer the evaluation will focus these effects. The number of participants reached will be one main indicator for gathering the attention of users for our game. We want to encourage users to explore Vienna using sustainable modes of transportation.

The evaluation of the project will analyse potential effects of our integrative approach. The field tests will take place in autumn 2015 involving a mobile survey, user diaries as well as qualitative interviews. The evaluation will demonstrate the usability and impact of the app, and its suitability for use in different contexts to promote sustainable mobility choices. This will be invaluable in establishing the potential for widespread and continued use of the app, beyond the life of the project. We expect to achieve significant statistical effects on motivation, game progress and user's engagement in comparison to baseline measurements with satisfactory p-values ($<.05$) and moderate to medium effect sizes ($d>.20$).

5. Conclusion

In this paper we presented the theoretical framework of our mobility app, which aims to promote multimodal mobility using elements from gamification, serious games and pervasive games. The synthesis of behavioral mobility models and motivational game models seems to be a valid approach for achieving a behavior change in terms of choosing sustainable models of transport. In order to foster transfer processes core game elements are placed both in the virtual and in the real word in course of the offline campaign. The impact of this approach will be evaluated using quantitative and qualitative methods. Preliminary results of the field test will be shown and discussed at the conference.

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System Design Requirements for Formal Education Based on COTS Entertainment Computer Games

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Abstract: Computer games can be designed as tools for school, but formal education can also be game-oriented based on dialogue enabling the use of commercial-off-the-shelf (COTS) entertainment games. The latter design was applied in two upper-secondary school trial educations, called the Digital Room. A problem is that teachers have to grade pupils based on assessment of the learning process through playing COTS games together with the pupils, while retaining compliance with the school regulations which can also change over time. The question is: what are the requirements for designing a system supporting teachers in bridging this gap? This paper describes and compares two trials of the Digital Room, enabling a long-term study between 2003-2013 with secondary school pupils and teachers. To answer the question in this paper, teachers from both trials were interviewed and situations were analysed based on a critical realist approach. Lack of time to manage and reflect on the documentation for assessment was a critical part of the results, and a teacher support system was explicitly asked for. Knowing what to document was crucial as games have many modes of expression, and understanding how to assess what has been documented was the hardest part. Conclusions are that a knowledge management system (KMS) could aid teachers in supporting each pupil to fulfil their goals and the requirements of the existing school system. Due to the expressed lack of time for management and assessment of documentation, the KMS should compile the data of each pupil's actions in the game as basis for grading. Further, this KMS could be used for further learning by combining explicated knowledge from the socialisation process. Pupils could also add explicit information to the KMS about findings on the Internet and from oral dialogue with peers and teachers. Thus, the KMS must enable multimodal expressions to be as accessible as possible, including pupils with impairments. Information must be searchable and sortable which can be a challenge to achieve with other modes of expression than text. Further, the KMS design has to include both pupils and teachers in evaluations, and be easy to adapt when new regulations create new conditions. Future research includes implementing and evaluating the system in a similar game-oriented formal education context outside of traditional school.

Keywords: game-based learning, teaching with computer games, assessment, knowledge management, system design, COTS

1. Background

Game-based learning implies that computer games can be designed for education, i.e. serious games (Al-Washmi et al., 2014, Amresh et al., 2014, Forlizzi et al., 2014). Students designing educational games for teaching (Gerodetti and Nixon, 2014) is a learning approach in itself. Further, game mechanics can be introduced in educational contexts for gamification (Hammais et al., 2014, Mavridis et al., 2014) and as live-action role-play (Gjedde, 2014).

Also, commercial off the shelf (COTS) entertainment computer games can be used with focus on socialisation, which requires a pedagogical change of formal education rather than game design, as is explained in previous studies of the Digital Room (DR) (Wiklund and Ekenberg, 2009, Westin and Lange, 2012, Wiklund et al., 2014). This change is not gamification (adding game mechanics to traditional school); instead the DR is a game-oriented formal education from the ground-up, where both the schedule and schoolbooks are replaced with a structure, which enables gaming and having a dialogue with gamers about curricula in a way they find meaningful. The basic structure was a minimised schedule, i.e. a full workday which started in the morning and ended in the afternoon. The content of schoolbooks were replaced with the knowledge created in dialogue between teacher and student, related to the curriculum. Also, online sources of information were used as part of the dialogue. The DR was conducted in two trial upper-secondary education projects, enabling a long-term study between 2003-2013.

The game-oriented educational design of the DR was clearly appreciated by pupils who had previously been excluded in traditional school (Wiklund et al., 2014). The DR was based on playing COTS computer games together with the pupils and having a dialogue related to educational goals. Most of the pupils became highly motivated to learn (in contrast to their previous school experience), which can be a problem with a serious games approach (Farrell and Moffat, 2014). The DR has potential to genuinely transform, as described by Freire (1974), the situation for pupils who are excluded in school and who are also gamers. However, the non-deterministic control systems and testing in traditional school is a barrier as explained in (Westin and Lange, 2012). This in turn requires that the reification of traditional school as an institution (Berger and Luckmann, 1991) is broken or worked around by implementing other forms of formal education.

Further, assessing learning through COTS games (not designed for formal education) in relation to educational goals can be a challenge for teachers. Serious games on the other hand, can have embedded assessment functionality; Chaudy et al. (2014) presents an assessment engine where assessment can be modified by the teacher, independent of the game. The lack of similar built-in support in COTS games for assessment related to curricula is a barrier, which needs to be addressed. As COTS games are mostly propriety software it can be difficult or impossible to integrate third-party software, depending on whether the game has an application programmer interface (API) and what the API allows third parties to implement. Thus, to be useful as a generic tool the assessment system must be completely game agnostic. König et al. (2014) have developed an interactive toolkit for teachers, supporting the teacher in using GBL in the classroom situation. Handling assessment and grading is not a new problem; Freinet (1969) created a system of his own (without computers) for filling in lists required by school so he could focus on teaching instead. A similar system supporting teachers in the DR where the traditional classroom is replaced with a digital room requires a different set of tools.

Knowledge management systems (KMS) handle the flow of tacit knowledge in an organisation enabled by socialisation, by making the knowledge explicit and externalised. This explicit knowledge can then be combined and internalised by others (Judge, 2010). A group of gamers, e.g. a guild or a class playing a game in an educational context, can be viewed as an organisation with a complex learning process related to educational goals. A difference with a KMS for formal education (compared to a business organisation) is that the sharing of knowledge is primarily with the teacher for assessment and not with peer pupils (or co-workers). The teacher has to assess and then explicate what the pupil has learned, as basis for grading. The assessment can be formative and summative, related to both overarching and specific subject learning goals of the curriculum. However, the KMS could also be used for further learning by combination and internalisation.

Computer games include a variety of multimodal expressions such as character animations and voice chats, which are less common in other computer applications. Thus, a KMS for game based learning need to be able to capture visual and auditory information in real-time without affecting user experience of the game. Further, such a KMS must analyse the captured files to enable searching and sorting of the content, e.g. by applying voice recognition, optical character recognition or pattern recognition of e.g. how a character looks and acts in the game.

Requirements are in this study viewed as a design proposition based upon previous scientific work and curricula, which should be tested in practice. This can be done based on a critical realist approach, with Bhaskar's real, actual and empirical domains as described in (Carlsson, 2010). The real domain is the mechanisms in COTS games related to formal education; the actual domain consists of events and behaviour in COTS games related to formal education; and the empirical domain is what pupils and teachers experience. The concept of breakdown occurs when the habits of everyday life breaks down; something is ready-to-hand when habits work, and present-at-hand when a breakdown occurs (Winograd and Flores, 1986). Breakdowns are useful for analysing teacher experiences in the empirical domain.

The requirements for designing a KMS for supporting teachers, should also relate to five constructs for implementation of a knowledge management system (Judge, 2010): 1) Permeable barriers, e.g. incentives for pupils and teachers to use the system, 2) Value accelerators, e.g. integrating with the game to ease assessment and aid the learning process, 3) Portals, to capture and access stored data with an external client, 4) Knowledge Management Technology Modules, for managing information packages, and 5) Knowledge Flows, which are socialisation, externalisation, combination and internalisation.

Related to the use of a KMS in formal education, there is an issue of accessibility as public schools must be inclusive for all pupils. The International Classification of Functioning, Disability and Health (ICF) is a *"bio-psycho-social model"*, which *"represents a workable compromise between medical and social models of disability"* (World Health Organization, 2011 p.4). In other words, ICF dissolves the line between disabled or not into a continuum, making accessibility relevant for all. The design of the KMS must consider accessibility for assessment of what has been learnt to avoid breakdowns for the pupils (in what ways they can express themselves and interact with the KMS) and for the teachers (how they can access the KMS content and understand what the pupil has learned). To evaluate the KMS, criteria for success can be found in (Dehghani and Ramsin, 2015).

The problem is that teachers who wish to transform formal education with the DR approach, have to bridge (at least) one gap: they have to be able to grade pupils based on evaluation of the learning process by pupils playing COTS games, while retaining compliance with the school regulations. This problem is based upon the previous studies of the DR. The question is: what are the requirements for designing a system supporting teachers in bridging this gap? Successfully answering this question enables a design for learning in formal education, which has been clearly appreciated by pupils who were both excluded in school and gamers.

2. Method

As the study aimed to explore requirements for the creation of a system, a design science framework was needed. Design science is probably most clearly differentiated from other frameworks by its strong focus on creation of an artefact: *”The fundamental principle of design science research is that knowledge and understanding of a design problem and its solution are acquired in the building and application of an artefact.”* (Hevner and Chatterjee, 2010 p.5) More specifically, this was conducted by investigating requirements for a knowledge management system (KMS) for supporting teachers, which is clearly a sociotechnical system. This required a critical realist approach:

> *”The approach builds on the premise that one of the most critical aims of IS design science research is to develop practical knowledge for the design and realization of different classes of IS initiatives, where IS are viewed as sociotechnical systems and not just IT artefacts.” (Judge, 2010 p.209)*

The design and use of a information system (in this case a KMS) is also a way to achieve transform (or change): ”a focus on how information technology and IS can be used to change (transform) an organization or a network of organizations.” (Carlsson, 2010 p.213). Critical realism takes the realist perspective (natural order) and applies it onto social events and discourses. Bhaskar (1978) in Hevner and Chatterjee (2010) provides a concept, which is useful for analysis from a critical realist perspective. It is based upon three domains:

- The real domain: Consists of structures and mechanisms, which produce patterns and events as well as relations (generating behaviours). These do not emerge from the background without social science theory and practice, e.g. different consequences for education of change in curricula and school regulations.
- The actual domain: observable patterns or events occur within a context, here two trial educations (DR1 and DR2)
- The empirical domain: this is where teachers experience the generated events

An important point is made by Carlsson (2010) that it is not IS initiatives that work; it is the practitioners (here the teachers) that make them work. This paper describes and compares two separate studies of the Digital Room (DR1 and DR2). Two teachers (one from each study) were interviewed about their view of the DR and specifically related to assessment and grading. The teacher from DR1 was interviewed again in 2015 to follow-up what the teacher in DR2 said and be able to make a better comparison of their views. The interviews were semi-structured which kept the interview focused but also allowed for the teachers to talk freely. Their different views were then compared related to the different situations at DR1 and DR2, analysed with Bhaskar’s three domains.

The credibility of the study (Creswell, 2013) can be motivated by the fact that the main author was involved in both DR1 (as a supporting teacher in game development) and in DR2 as a participant observer, at least once a week continuously for two years. The second author created the DR and were also a teacher in practice at DR2, although not formally and did not grade the pupils. With the study of two different trials during 2003 to 2013 the results should also provide enough detail for transferability. All of the authors have published research related to the DR. Ethical considerations was based upon Denscombe (2010 pp.331): The teachers were informed that the data would be presented in such a way as to not reveal the identity of a specific person. Further, the purpose of the study was expressed and they were given the opportunity to confirm the transcriptions of the interview.

3. Results and analysis

In DR1, two teachers who were dedicated to the game-oriented design handled the grading process. In DR2, the grading process became more complicated due to several factors, such as: 1) There was a new school system (Gy-11) introduced mid-project, 2) an increased number of grades required to attend secondary education, 3) the grade system changed to six grades (A-F), and 4) all teachers had to be certified to be able to set grades, narrowing the possibility to find dedicated gamers as teachers.

Recurring patterns regarding evaluation of learning processes were: 1) language could be handled well inside the game itself with text chats but also with external voice chat applications, e.g. assessing how pupils expressed themselves including grammar, 2) math could be managed to some extent e.g. with the auction house in World of Warcraft, and 3) social sciences and history could be managed partly in-game but mainly through dialogue about game content; e.g. to understand aims in the curriculum of understanding political systems and history by comparing events in game worlds with the actual world. In both DR1 and DR2 one game in particular was used as a common digital room (World of Warcraft) although pupils also played other games, e.g. Heroes of Newerth and Counter-Strike.

During the first year of DR2, a certified teacher (T2) who was also a gamer was recruited. As such she had deeper insights than the other teachers into what the problems and possible solutions for using COTS games in education were. She was also able to easily establish a good communication with the pupils, as she could play together with them. She had several concerns regarding assessment presented below, for instance regarding time:

> *"When I am in the activity I am simultaneously supposed to assess the pupils, enabling them to develop from what they are doing well and what they can improve. It is very hard when both the pupils and I are here all the time. You need time to reflect on how it went and get support in the documents." (T2, translated by the authors).*

While lack of time is not a specific concern of the DR, the dialogue based and game-oriented design naturally requires more time *"in the activity"* compared to a more traditional school form, where reading schoolbooks has a central role in transferring content. The teacher in DR1 (T1) explained that you are always in the activity with the pupils: *"you don't get rid of them, not even in weekends because of the gaming"* and that *"you get a better insight into each individual's strengths and weaknesses for better or worse"* compared to traditional school. Another concern related to assessment was agreeing on which game to play and meet in:

> *"Games are accessible, you can easily meet in the same place, but it is hard when the pupils don't play the same game as me. I can't play ten different games; that is unrealistic. I teach language and the pupils can train their skills on their own in the games but to assess them, I need to be in the same digital room at some point in time." (T2)*

This quote is from the first year of DR2, and the problem gradually diminished over time when the group process had evolved. T1 explained that in DR1 this was not a problem as the main game used in both DR1 and DR2 (World of Warcraft) was new at the time of DR1 and almost everyone wanted to play it anyway. T1 also said that in the DR *"all doesn't do the same thing at the same time as in a traditional classroom, but you wander around among them"*. Still, even when playing the same game at the same time, it is hard to document the process as a teacher while you are involved in the gaming. T2 explicitly asked for a system for teacher support when using COTS games in a formal education context:

> *"What is hard is to document it. I have tried to take screenshots of the chat and saved it, when there has been some interesting discussion with a pupil. However, it would help if there were a system where you could save the entire conversation in an easier way." (T2)*

T1 said that main problem is not documentation itself (you can save conversations as chat logs and make screencasts or screenshots) but how to assess, and what to document as games have many modes of expression, e.g. graphics, audio, motion, cooperation and speech. The material has to be *"sorted, searchable on each pupil, on events in time and so on"* (T1). Also, he noted that for integrity reasons only relevant material should be stored (which requires searching and sorting), within the same limits in time as other forms of examination. As COTS entertainment games are both unmodified for educational purposes and propriety software this has to be implemented with a game-agnostic approach, i.e. without requiring access to game content via an API. If this was possible, the teacher could focus better on teaching and helping the pupils, rather than managing documentation. This would free up time for more pedagogical activities:

> *"I think you could work with World of Warcraft if you only had time and possibility to look at the structure in the game and compare it with a regular society structure, check how the economy works and such. I believe in the idea but there must be more teachers who can do it. Math, you can do how much math as you like in the game." (T2)*

The quote above also reveals another time related dimension, which relates to how few teachers are literate enough in games. There must be more than one or two certified teachers at a school who are able to play the games together with the pupils. Another issue is how existing systems in schools are designed for traditional education with a schedule, which may be a problem if the schedule is replaced with a full workday as in the DR:

> *"It is hard as the school administration has other systems we don't use; our lessons are not in their systems, so I had to create a system of my own to keep track of attendance. Also their system requires PC but I have a Mac." (T2)*

This means that existing systems and policies in formal education are designed for traditional school, where the education and assessment must be done in a specific way to not cause a breakdown. This issue goes beyond the scope of this paper, but is also a system related issue that must be considered. To design a system for teacher support related to COTS games, the situations at DR1 and DR2 can be compared and analysed using a critical realist approach, see Table 1.

Table 1: Domain based analysis of situations at DR1 and DR2

Domains	DR1	DR2
Real: Mechanisms	Main digital room: World of Warcraft	Same as in DR1
	Certified teachers not required with the old curriculum (Lpf-94)	All teachers required to be certified with the new curriculum (Gy-11), introduced mid-project
	Local personal computer (PC) management in the school	Centralised PC management of all schools in the municipality
	Gaming PCs purchased for the trial education project externally, managed by the pupils and teachers	Same as in DR1
Actual: Events and behaviour	Teachers with a gaming interest were recruited internally within the municipality	Teachers with a gaming interest were recruited externally
	No notification to School Inspectorate	Anonymous and erroneous notification to School Inspectorate
Empirical: Teacher experiences	T1: Lack of time for managing documentation (sorting and searching) in various forms (screen recordings, chats etc). Knowing what to select and how to assess is the hardest part.	T2: Lack of time for documentation and reflection, relating to documents and comparing structures in games and society.
	T1: A system for assessment and documentation was confirmed in the interview.	T2: Explicit request of a system for assessment of language learning in COTS games

From the domain analysis of teacher experiences, it is clear that time was a central barrier for going further with pedagogical activities with the games. The need for a system to support assessment was also clear as a possible solution to the lack of time. It should further be noted that the notification of DR2 to the school inspectorate, consumed significant amounts of T2's time with the pupils.

4. Discussion

Based upon school regulations and the empirical findings a number of requirements can be related to the Knowledge Flows construct: socialisation, externalisation, combination, and internalisation. By participating in playing games together pupils and teachers socialise, creating tacit knowledge related to the curriculum.

Through dialogue, the teacher can ask questions related to curricula, but this dialogue is hard to capture while playing.

Tacit knowledge has to become explicate. Some skills are naturally explicated, e.g. expression through written text chats or voice chats, while other skills are harder to explicate in the game, e.g. math formulas. Tacit knowledge can be explicated in dialogue between pupil and teacher, where the challenge is to have this dialogue stored in an indexed, searchable format. For instance, text chat is easy to search and sort but recorded speech requires voice recognition processing for indexing the content, and correct voice recognition of speech is still a challenge to achieve.

The combination and internalisation constructs of the Knowledge Flows construct goes beyond the assessment level, and into further learning. Providing pupils easy access to their previous externalisations and combine them in new ways, would be useful for providing meaning to and internalisation of previous externalised knowledge, beyond grading. The ease of access is a Value Accelerator for both the pupil and teachers. Thus, considering how the Portal construct and the Knowledge Management Technology Modules construct could integrate with the game is important. By making the Portal accessible (both for pupils with impairments but also in a more general sense) and meaningful related to the game and education, the Permeable Barrier of Incentives can be achieved.

While time required for assessment was a central issue, there were several other time consuming factors in DR2 compared to DR1: the centralised PC management, the lack of more teachers who were both qualified and gamers, and the anonymous notice. Still there is no reason why a qualified teacher should have to spend time documenting in an unnecessarily time consuming way, if there are more time-efficient ways of doing it. With a KMS running in the background, the teacher could start the first game session by identifying the pupils in the game by character name, and then the KMS could track each pupil visible on screen as character or in text chat. For voice chat, pupils could identify themselves by talking to the teacher until the voice recognition software has enough data for recognition. Motion data from character animations could also be useful to understand more of the context of captured voice or text chats, i.e. what the pupil was doing while saying something.

5. Conclusions

To avoid breakdowns, conclusions are that the design requirements of the knowledge management system (KMS) are:

- Aid teachers in supporting each pupil to fulfil learning goals, by making the process of documentation and assessment as accessible as possible.
- Compile and select data of each pupil's progress in games as basis for grading, which minimizes the time required for managing documentation and assessment.
- Be easy to adapt when new regulations (e.g. Gy-11) create new conditions.
- Handle multimodal expression for inclusion of all pupils regardless of impairments and other limitations (social, cultural) to avoid disability.
- Be game agnostic as COTS games often are closed systems.
- Be useful also for handling knowledge based on other Internet activities and dialogue.
- Provide opportunity for further learning by combining and internalising knowledge in the KMS.

These requirements are useful for the initial design stage of a KMS for teachers and pupils. To implement the KMS in practice, both pupils and teachers need to be included in evaluations of the KMS design. Criteria for success of these requirements can be based upon the KMS evaluation framework by Dehghani and Ramsin (2015).

6. Future research

Future research is to design a KMS based upon the requirements found in this study, and conduct evaluation based upon (Dehghani and Ramsin, 2015). A possible venue to explore is to apply data mining algorithms, both in games and in the KMS to ease the process of grading. A related issue is to find out how information can be retrieved from games without requiring integration via an API. For external software used while playing, e.g. voice chat there may be a possibility to record the spoken dialogue to an audio file but this file must be stored and made searchable with voice recognition, which is not trivial. Another issue for future research is whether this KMS is enough to achieve genuine change of the situation for the pupils.

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Evaluating Educational Games Using Facial Expression Recognition Software: Measurement of Gaming Emotion

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Abstract: The issue of using educational games versus entertainment games as the base for learning environments is complex, and various data to base the decision on is needed. While participants' verbal accounts of their situation is important, also other modes of expression would be meaningful as data sources. The availability of valid and reliable methods for evaluating games is central to building ones that are successful, and should preferably include outside measurements that are less affected by the participants' choice of what to share. The present study considers a method using software for analysing facial expressions during gameplay, testing its ability to reveal inherent differences between educational and entertainment games. Participants (N=11) played two games, an entertainment game and an educational game, while facial expressions were measured continuously. The main finding was significantly higher degrees of expressions associated with negative emotions (anger [$p < 0.001$], fear [$p < 0.001$] and disgust [$p < 0.001$]) while playing the educational game, indicating that participants were more negative towards this game type. The combination of cognitive load inherent in learning and negative emotions found in the educational game may explain why educational games sometimes have been less successful. The results suggest that the method used in the present study might be useful as part of the evaluation of educational games.

Keywords: facial expressions, emotions, games, educational games, evaluation methods

1. Introduction

During recent years educational games have become an important learning tool (Eck 2006). However, using games for learning has not always been as successful as many had hoped (Ebner & Holtzinger 2007). Kirriemuir and McFarlane (2003) have identified common problems with educational games ranging from tasks that are too repetitive to games that are too simple compared to entertainment games. In some cases educational games have even seemed to combine the worst aspects of education with the worst aspects of games (Eck 2006). It is therefore critical for educational games to be both educationally sound as well as utilising core entertainment game concepts. Indeed, learning outcomes are deeply intertwined with the emotional state of the learner (Meyer & Turner 2006).

Gee (2003) argues that digital games, at least those that are well designed, inadvertently are effective learning devices, both for knowledge about the game itself, but more importantly for teaching players about the world around them. There are different ways of applying digital game-based learning, and Eck (2006) makes the distinction between using existing entertainment games in the classroom, and using games that are designed for the purpose of education. The latter games are sometimes referred to edutainment, a portmanteau for educational entertainment as they aim to be both educational as well as entertaining. An educational game can, of course, be entertaining in the sense that the player enjoys to play it, however it still aims to teach. Entertainment games do not explicitly need to have this aim.

The above definition of an educational game could be taken as contrary to Gee's (2003) definition that suggests that quite a few games could be considered educational even if it wasn't the primary intents of the game's creators. Gee´s definition however, is troublesome in that it makes it difficult to objectively declare a game to be educational. The only remaining objective definition is therefore a game where the creator has declared the game to be educational, which is the operational definition for the present study.

Self-reported questionnaires where players describe their experience of a game is a common way of evaluating educational games (e.g. Ebner & Holtzinger 2007). Such approaches are not without issues, as the meaning of self-reported data is difficult to ascertain. Recently attempts have been made using various psychophysiological methods to measure emotional response, including skin conductance and facial electromyography (Kivikangas et al. 2010). These methods however, have issues of their own (ibid.). Emotional facial recognition on the other hand, provides data that is both accurate and multifaceted (Kaiser et al. 1997).

Accurately measuring emotions would help researchers understand motivation in the learner, as emotions according to Izard (2009) play an important role for motivation. It should be noted that there is no direct link between simply the display of emotions during gameplay and the motivation in a learner. As one example, a learner may display expressions of disgust during an anatomy dissection session while still be motivated to proceed with his or her medical training. However, measuring signs of emotion may to some degree involve the mapping of facial expressions to emotions which is a complex task in itself. Even with this issue unsolved, the measuring of facial expressions themselves may provide interesting information. Further, little is known about the difference in emotional response to entertainment and educational games, respectively. If it is unknown to what degree these responses differ, developers lack information that may be important for the successful design of game based learning environments.

How do emotional facial expressions as measured by facial analysis software differ between games focused primarily on education versus entertainment games? Is it possible to use facial analysis software to obtain information relevant to the evaluation of educational games design?

2. Related research

Despite showing much promise, the adoption of digital game-based learning (DGBL) has been slow. Educational games, described by Eck (2006) as serious games, have been used with varying results both in terms of profitability and learning results. In less successful cases, one reason for the lack of success is that the games fail to engage their audience and thereby produce poor learning results (ibid.)

Initial forays into DGBL focused on concealing the learning educational aspects of the game, and making the gameplay aspects enjoyable (Kirremuir & McFarlane 2004). Later this approach has shifted towards a model based on flow theory, whereby designers aim to induce a higher degree of engagement referred to as flow (ibid). While the applicability of flow theory could be considered an open question, the earlier approach arguably neglects to cover important aspects of motivation.

Among other things, research on motivation for learning has focused on self-determination theory with three components: competence, relatedness and autonomy. The need for competence is the need to master a field and completing various tasks in that field, relatedness is the need to belong to a group, and autonomy is the need for control in the learning situation. (Pintrich 2003)

The autonomy of educational games could be considered one of its strengths; players are often very much in control of the learning environment. Relatedness may seemingly be more difficult, although online experiences may offer good relatedness. The competence component is another area where DGBL may prove useful, because games allow for easier ways to adapt the difficulty of tasks so as to be suitable to the individual.

Successful applications of educational games have been described by Ebner and Holtzinger (2007). Learning results were promising, and Ebner and Holtzinger (2007) also used a survey to measure whether the participants found the game to be enjoyable or not, concluding that the participants did indeed find the game enjoyable. Emotions are a key factor in motivation and therefore important to educational games (Izard 2009).

However, it is well established that respondents will be biased towards responding in a way that they consider to be socially desirable and that non-subtle questions are more likely to yield biased responses (Furnham 1986). Questions on overall game enjoyability may therefore significantly overestimate the player's actual feelings towards the game. In a meta analysis Mortel (2008) found that about half of the studies including components prone to social desirability issues showed effects of social desirability responding. Thus surveys in themselves are prone to response bias, in this case it may be socially desirable for the participants to report that they did enjoy playing the game.

The degree to which a game makes the player experience emotion, the perception of an emotion, controls the motivation of the player (Izard 2009). However, asking participants simply to rate their enjoyability of a game may fail to capture other emotions that were present. A more complete picture of the player's emotions could yield more information about the player's motivation.

Another issue with using self-reported ratings of various emotions is that the rating is performed after finishing playing the game. The ratings therefore may be affected by the degree to which the participant recalls the events. The emotions felt towards the end of a series of events carry a greater weight in the participants rating thereof (Redelmeier et al. 2003). Supplementing statements regarding player opinions with quantitative, measured data therefore provides an advantage over using purely qualitative data alone.

Many of the aforementioned problems with self-reported emotional valence can be avoided by measuring psychophysiological responses (van Reekum et al. 2004). A common way of measuring emotional response is skin conductance, which has been used in several gaming related studies (van Reekum et al. 2004; Conati 2002; Ravaja 2005). While skin conductance can be used to objectively measure goal conductive as well as goal obstructive events, they both cause an increased skin conductance response (SCR) (van Reekum et al. 2004), thereby making it difficult to distinguish one from the other. For this reason SCR, is not ideal for measuring game engagement.

In addition to SCR, Facial electromyography (EMG) is sometimes used. EMG measures the activation of the muscles of the face and can therefore be used to distinguish positive and negative valence (Kivikangas et al. 2010). It is however susceptible to noise both from muscle activity not related to emotions and from poor electrical contact (ibid.). This results in weak statistical power, requiring much larger sample sizes.

EMG using facial electrodes may also affect the performance of gaming related tasks as players may act differently when wearing electrodes. Facial electrodes might also make it difficult for the subject to concentrate on the task at hand. All in all, psychophysiological methods show some promise for evaluating games, but have issues both regarding the richness of the data and how measuring process may affect the gaming activity.

Facial expressions however communicate a wider range of emotions than the simple measure of skin conductance provided by SCR. The study of facial expressions has gathered much interest, with researchers as early as Darwin (1872) contributing to the field. Two primary research issues with facial expression are cultural invariance and the degree to which facial expressions are consciously controlled.

The issues of cultural variance involves whether expressions are innate or whether every culture have expressions on their own. Ekman and Friesen (1969) divided human facial expressions into six different culturally invariant categories with corresponding emotions. The emotions defined as having culturally invariant expressions were happiness, anger, contempt, disgust, surprise and fear. Based on these emotions Ekman (1978) created the facial action coding system (FACS), which maps emotions to movements in the face. An opening of the mouth and raising of the eyebrows for example codes for an expression of surprise, and imilar coding rules exist for other emotions.

The degree to which humans can control facial expressions is debated, with authors such as Ekman (1997) arguing that emotional facial expressions are largely involuntary. Other authors such as Blair (2003) hold it to be a means of communication, therefore more likely to occur in the presence of others and involving both conscious and unconscious processes. All in all, facial expressions, while sometimes consciously modulated are generally coherent with the emotional state of the emoter (Blair 2003; Ekman & Friesen 1969; Ekman 1997). In the light of this, emotional facial expression could be considered a more interesting indicator of emotional state than either self-reported or psychophysiological data.

Using FACS to code emotions manually would be extremely time-consuming, and would not be feasible for evaluating games considering that meaningful playing sequences may range from several minutes to hours in length. It is however possible to automate the process of classifying facial expressions and accuracy has been steadily improving (Valstar et al. 2012), enabling large scale analysis of facial expressions. The results from earlier gaming related studies using automatic processing of facial expressions based on FACS (Kaiser et al. 1997) merit a study focusing on comparison of educational games and entertainment games.

3. Method

An experiment with an in-between group design was conducted for the test. Eleven participants (m_{age} = 25.90, s_{age} = 5.33), five males and six females were recruited among Psychology and Computer Science students at Stockholm University. Each participant was randomly assigned to one of two groups. Each group played two games, one educational game and one entertainment game. The first group played the educational game followed by the entertainment game, while the other group played the games in the reverse order, thereby eliminating effects of order The participants where positioned at a distance of approximately 50 centimetres from the display. After ensuring that the participant was properly placed within the frame of the camera mounted on top of the monitor. The participants played each game for 20 minutes, for a total of 40 minutes of gameplay per participant. After completing both gameplay sessions the participants were asked to fill out a short questionnaire containing questions such as age and gender, which were used to calibrate the facial analysis model.

The entertainment game used in the present study was Lux Delux, a strategy game by Sillysoft (2008). Lux Delux has few learning elements and does not embed any explicit knowledge other than a world-map divided into very coarse-grained regions. The game is played exclusively using the mouse. The educational game played was the Great Flu, a simulation game by Ranj Serious Games. In the Great Flu players, faced with a global pandemic are tasked with combating it using various actions target to specific regions on a world map. This game aims to teach players both about effectiveness of various interventions as well as the politics and ethics of enacting them. Like, Lux Delux, the Great Flu is also played solely using the mouse. The two games were chosen because the game mechanics are similar; both use a world map as the set that the player manipulates. Both games were run on standard PC hardware, running the Microsoft Windows 7 operating system.

Subjects were video recorded during the gameplay and the first thirty seconds of video were subsequently cut out of the video files, so as to ensure that the player had begun playing before analysing data. Recorded video sequences were processed using Noldus FaceReader (Noldus Technologies 2012). The program generates time-series for each emotion (happiness, anger, surprise, fear, contempt and disgust) as well as a value, neutral describing the degree to which emotion was not present. A log-transform was then performed for each emotion separately, to ensure a Gaussian distribution. The mean and standard deviations of the time-series for each emotion were then computed, and t-tests were performed.

4. Results

The overall arithmetic means and standard deviations for each expression after the log-transform were: neutral ($m = -0.9333$, $s = 0.8699$), happiness ($m = -4.732$, $s = 2.510$), sadness ($m = -2.012$, $s = 0.9861$), angry ($m = -3.758$, $s = 1.382$), surprised ($m = -5.613$, $s = 1.28$), scared ($m = -8.55$, $s = 1.84$), and disgusted ($m = -6.507$, $s = 1.85$). Upon inspection of kernel density estimates for the data, it was held to be of from a Gaussian distribution.

In the complete data set there were 33 844 missing values out of a total of 949 429 observations, for a total of 3.5% missing values. Missing values were caused by either by the software failing to find the face or the software failing to process its expressions. No distinction was made between failures to find the face versus failures to process its emotions. No interpolation was made for these missing values; they were simply dropped from the data set. The median length of a period of missing values was 56 seconds, however only 16 periods of missing values were present in data.

The dataset was then split by condition, such that sequences where the Great Flu and sequences where Lux Delux were separated into groups, see Figure 1. T-tests for repeated measures were then performed comparing the two games for each emotion time-series. The p-values were adjusted for repeated tests using Holm's (1978) method. These are presented in Table 1.

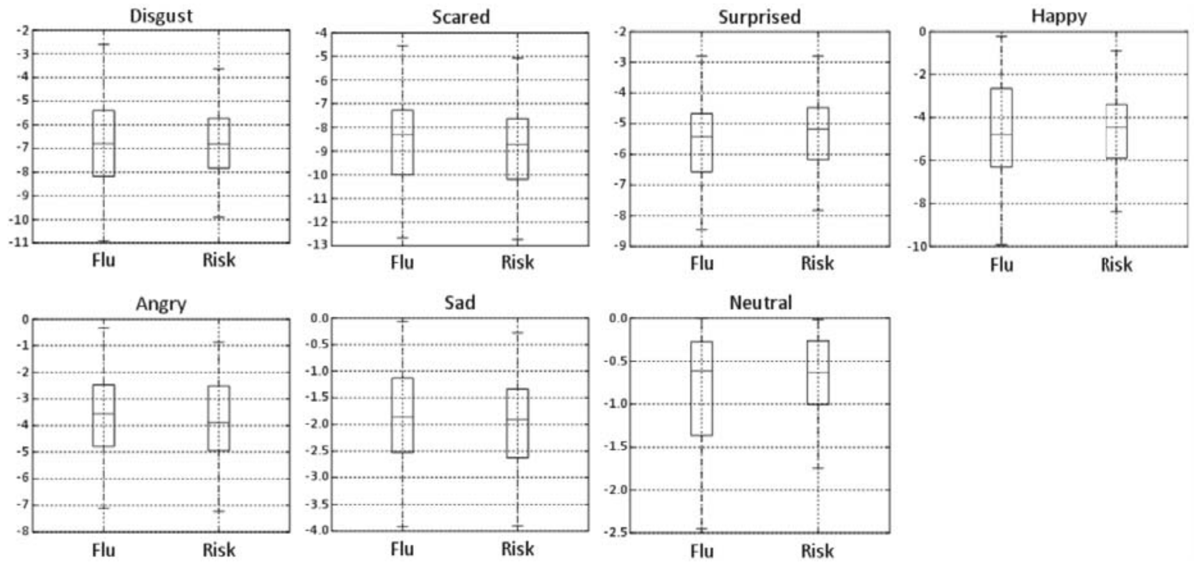

Figure 1: Box-plot for the emotions, split by condition. Flu = the Great Flu, Risk = Lux Delux

Significant effects were found for each emotion, even after adjusting the p-values for multiple comparisons as shown in Table 1. Greater degrees of happiness ($p < 0,01$), anger ($p < 0,001$), fright ($p < 0,001$), and disgust ($p < 0,001$) were found for the educational game over the entertainment game. The effect on happiness was relatively minor, $t = 3,11$, while the other differences were much larger.

Table 1: T-values, degrees of freedom and adjusted p-values for the t-tests performed between the two games

Emotion	t	df	p adj.
Neutral	-205,20	652 074	<0.001
Happy	3,11	847 803	<0.01
Sad	70,08	914 661	<0.001
Angry	41,08	904 914	<0.001
Surprised	-166,50	886 889	<0.001
Scared	105,86	911 631	<0.001
Disgusted	17,67	887 331	<0.001

5. Discussion

The results showed that while playing the educational game, players showed significantly less facial expressions of surprise than they did when playing the entertainment game. In addition, while playing the educational game players showed more expressions of anger, fright, disgust and interestingly happiness. In case of the effect on happiness the difference was very slight, though still significant. While playing the educational game, players had a significantly lower degree of neutral expressions.

Emotions of anger, fear and disgust are all negative expressions, which could be taken as an indication that participants had a more negative valence towards the educational game. However, there is no direct link between displays of emotion alone and attitudes towards a game. In an example similar to that used in the introduction section, a player may be showing disgust in an anatomical dissection situation in an educational game while still having a positive attitude towards the game as it enables him or her to undertake valuable medical training.

Therefore it is difficult to say if the detected negative expressions suggest that participants had more negative attitudes towards the educational game. It is unclear if these stemmed from the subject matter of the game or from the gameplay itself. Strong emotions, whether negative or positive, can increase and decrease motivation depending on the cognitive context. Conflicting information of some kind, which may cause initial negative emotions, has been found useful to some degree and may be accompanied by positive emotions after accomplishing such a task (Leutner & Detlev 2014). This notion is further supported by Mayer (2014).

If however, players have negative emotions such as anger, disgust and fear towards the game this may result in the player avoiding the learning situation altogether (Meyer & Turner 2006). It should be noted that what was measured in the present study was facial expressions of emotion during gameplay, which is not the same thing as the players' overall emotion towards the game itself. Moreover, Meyer and Turner (2006) found that negative affect, as the negative facial expressions are an indication of, results in a failure to induce learning for mastery. This refers to a situation with applied learning objectives, connected to learning for mastery, such as for example becoming an excellent craftsman of some sort. With another type of learning objective, in-game renditions of horrific historical ordeals such as those experienced by the victims of the World War II Hiroshima bomb may naturally result in the display of negative emotions while still inducing desirable learning. Our results therefore, seemingly showing higher degrees of negative emotions when playing the educational game, may be indicative of a poor educational game in some cases of applied learning objectives. In other cases this could be seen as expressions of normal emotions when confronted with particular content in a well designed educational game containing negative examples.

If facial expressions are primarily used to communicate in the presence of others as Blair (2003) postulates, this may effect the interpretation of the data gathered through the method used in our study. Displays of facial expressions seem to be governed to some extent by the sociality of the situation that a person finds him or herself in (Chovil 1991). It could be that the lack of social interaction in the experiment caused the participants to display less facial expressions then they would have in a more social situation. A more social situation could result in more accurate data when applying the method of the present study. Such changes though, can impact results in other ways. Future research may focus on how different social gaming situations affect displays of facial expressions, comparing for example online to offline multiplayer games, or degrees of interaction with the evaluator.

Results also showed a few extended periods of missing values. During these periods the participant had either moved the face out of frame or tilted the head to such a degree that processing using the software became impossible. Some non-facial displays of emotions may make the processing of facial expressions impossible by obscuring the face. Emotional body language, such as covering the face are important in communication and involves the many of the same areas of the brain as facial expressions (de Gelder 2006). Emotional body language however is not captured by a classification system such as FACS, which the software used in the present study is based on. It is reasonable to assume that periods of missing values may be indicative of emotions, rather than simply noise. The possible solution is two-fold: firstly subjects need to be informed when they are outside the frame of the camera and secondly analysis software should include processing of gestures. Emotional body language is much less studied than that of the face (de Gelder 2006) and there does not seem to be any generally available emotion recognition software for body language.

Because the present study investigates game sequences that are 20 minutes in length, it fails to capture specific events in the game — A 5 second portion of a 20 minute dataset is simply too small. Future research could integrate event reporting into the games under evaluation. This would allow researchers to investigate the player’s emotional state both before and after an in-game event. Such data would enable producers to identify different areas of the game which are in need of improvement and also allow for more accurate evaluations of games overall, possibly distinguishing between sources of affect such as particular in-game events as opposed to the game itself.

Moreover, event-related methods would allow us to compare data prior to an event with data immediately following it, thereby accounting for the emotional state immediately preceding events. Such methods for game evaluations have been successfully applied in earlier studies, but not while measuring emotional facial expressions (Ravaja et al. 2005). Combining event-related methods with measurements of facial expressions could be an interesting research area, even if this in many cases would require access to the source code of the game itself.

Despite the issues presented, it seems probable that using the method for evaluating games may be worthwhile. The present study used a reasonably small sample of players, yet was able to establish differences between the games with large degrees of certainty, even without considering events within the games themselves. The apparatus required to use the method is relatively simple and inexpensive, and the method may therefore be a reasonable choice for evaluating educational games.

6. Conclusion

The present study showed that there are clear differences in measured emotional facial expressions between an educational game and an entertainment game. Participants showed more negative facial expressions when playing the educational game.

The method used was relatively simple to apply and offered good quality of data, especially considering the inexpensive equipment. The method showed promising results in that significant effects were found for even relatively small amounts of data, in this case eleven participants playing for 40 minutes each.

While the deeper meaning of the observed facial expressions remain uncertain, the data is still useful as input in an evaluation process of a game based learning environment, most likely in combination with interview data on the participants' perception of the emotions involved.

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The Role of Surprising Events in a Math-Game on Proportional Reasoning

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Abstract: Reviews regarding serious games show that the effect on learning can be qualified as moderately positive. Despite the active involvement of players it seems that they sometimes refrain from relevant cognitive processes during game play. This study addresses a technique involving the generation of manageable cognitive conflicts to stimulate these cognitive processes. Surprise comprises events that undermine an expectation which trigger players to evaluate the new situation more extensively. Participants (N = 94) played a game in which they practiced proportional reasoning skills. The pretest-posttest design involved two factors: *Surprise* (surprise vs. no surprise) and *Expectancy* (strong vs. weak). Surprise was implemented as an appearing game character that modified some parameters of a problem while the player was solving that problem. We expected that this would prompt players to evaluate their solution strategy and decide whether another strategy was more appropriate. Expectancy pertains to the type of problems that players expect. In the strong expectancy version players received a series of problems with the same structure as before. In the weak expectancy version problems with different structures are randomly presented to the players and each problem may involve a different solution strategy. We hypothesized an interaction between Surprise and Expectancy, next to a main effect of Surprise. The results show that participants learned from the game. We also did find a weak positive effect of Surprise, but no effect of Expectancy nor interaction effect on learning. The facilitating effect of Surprise was stronger when existing proportional reasoning skill was included as factor. These results indicate that surprise as implemented in the game has effect on learning regardless whether expectancy was weak or strong. We discuss some suggestions for finding stronger effects of surprise such as the fact that the repetitive nature may have weakened the 'surprisingness' of the surprises and the observation that our sample may not have possessed a sufficient level of metacognitive skills to interpret the changes caused by the surprises.

Keywords: serious games, mathematics, surprise, learning, motivation

1. Introduction

Despite the increasing popularity of serious games or game-based learning (GBL), recent meta-analytic reviews have shown that GBL is only moderately more effective and not more motivating than traditional instruction (Wouters et al., 2013, Clark, Tanner-Smith & Killingsworth, 2015). For example, in their meta-analysis Wouters et al. found only a moderate effect size (*d* = .29) for learning in favor of GBL. Likewise, they found a moderate, but statistically non-significant, effect for motivation in favor of GBL. GBL influences learning in two ways, by changing the cognitive processes and by affecting the motivation (Wouters et al., 2013). Preferably both mechanisms should be applied in order to maximize learning. A potential problem with GBL is that the outcomes of players' actions in the game are directly reflected in the game world. This may lead to a kind of intuitive learning: players know how to apply knowledge, but they cannot explicate it. In other words: they don't necessarily acquire the underlying rules (Leemkuil & de Jong, 2011). It is possible that studies therefore find no relation between success in the game and success on a knowledge test. The articulation of knowledge is important, because it triggers learners to *organize* new information and *integrate* it with their prior knowledge (Mayer, 2011, Wouters, Paas & van Merriënboer, 2008) and thus construct a mental model that is more broadly applicable. This implies that genuine learning in GBL requires additional features in the game that will provoke the player to engage in the process of knowledge articulation. Typically in learning environments such knowledge articulation is often prompted by explicitly asking learners to reflect on their actions and thoughts. In GBL, however, such an intervention may compromise the motivating or engaging quality of the game because it is likely that it will disturb the flow of the game, and consequently undermine the entertaining nature of the game and reduce motivation and learning as well.

The question raised in this paper is how we can stimulate players to engage in relevant cognitive processes (organizing and integrating knowledge) that foster learning without jeopardizing the motivational appeal of the game. A promising technique is the generation of manageable cognitive conflicts by introducing surprise. Surprise involves an emotional reaction, but it also serves a cognitive goal as it directs attention to explain why the surprising event occurred, and to learn for the future (Foster & Keane, 2015; Howard-Jones & Demetriou, 2009; Ranganath & Rainer, 2003). On the domain of narratives and text comprehension it has been shown that surprise has a beneficial effect on learning. Hoeken and van Vliet (2000) found that surprise improved text comprehension and appreciation more than other techniques such as events that aroused curiosity and suspense. Likewise, O'Brien and Myers (1985) confronted participants with a word that was either predictable or unpredictable from a preceding context and observed that the texts that preceded unpredictable words were better recalled. In the context of learning a medical procedure with as serious game van der Spek, van Oostendorp and Meyer (2013) demonstrated that surprise yielded superior knowledge structures, indicating that such events foster deep learning.

Readers understand a story because they construct a situation model in which dimensions such as time, space, and causality are related. Likewise, in computer games players construct a mental model and/or situation model based on the story line, the events and the underlying rules of the game (van der Spek, van Oostendorp & Meyer, 2013). The situation or mental model makes new events plausible (although such events may cause adaptations in the model) and is the starting point for expectations of the reader or player. A surprising event on the other hand is unexpected and not logically follows from the situation/mental model. Readers/Players will wonder what they have missed and start to re-evaluate preceding events. In this process the mental model will be activated, retrieved and updated, thereby enhancing learning.

The assumption of this study is that the effect of surprise also pertains to problem solving in serious games. Ideally, the mental model will enable the learner to recognize specific characteristics of a problem and how to solve that problem. When a surprising event changes some of the problem characteristics, the chosen solution is no longer applicable and the player has to re-evaluate the situation and decide which problem characteristics are relevant and which solution is now most appropriate. We expect that surprise has a positive effect on learning because it stimulates relevant cognitive processes such as organizing and integrating information without compromising the motivational appeal of computer games. In addition, we expect that the effect of surprise depends on the strength of the expectation: the stronger the expectation, the stronger the unexpectedness of 'surprisingness' of the surprise and thus the necessity to re-evaluate the situation. Taken together, we hypothesize an interaction effect of surprise and expectancy, next to a main effect of surprise.

In this study we investigate the impact of surprise on learning and how this impact is moderated by the expectancy of the learner. We used the GBL environment 'Zeldenrust' that was specifically developed for learning proportional reasoning in secondary prevocational education (see VanderCruysse et al., 2014). Proportional reasoning was chosen because it is a relevant and well-defined domain and existing methods for proportional reasoning are often ineffective (Rick, Bejan, Roche & Weinberger, 2012).

2. Method

2.1 Hypotheses

We tested three hypothesis:

> *Playing the game will improve learning*
>
> *We expect that surprise will increase learning more because it triggers students to interpret the changes in the problem characteristics caused by the surprise and the consequences for the solution process.*
>
> *In addition, we hypothesize that surprise after multiple problems with the same characteristics will have the largest learning effect because the unexpectedness of the surprise will incite students more to think about the changes in the characteristics of the problem characteristics caused by the surprise and the consequences for the solution process.*

2.2 Participants and design

The participants were 94 students from second year prevocational education with a mean age of 13.9 (*SD* = .81) recruited from five classes of one school. They were randomly assigned to conditions. We adopted a pretest-posttest design with the independent variables *Surprise* (Yes or No) and *Expectancy strength* (Strong or Weak) resulting in 4 conditions: Surprise and Strong expectancy (N = 22), Surprise and Weak expectancy (N = 23), No surprise and Strong expectancy (N = 26) and No surprise and Weak Expectancy (N = 23). The dependent variable was proportional reasoning skill.

2.3 Materials

2.3.1 Domain

The domain of proportional reasoning comprises three problem types: comparison problems, missing value problems, and transformation problems (cf., Tourniaire & Pulos, 1985). In comparison problems learners have to find out whether one proportion is "more than", "lesser-than" or "equal to" another proportion. These problems can be classified in difficulty levels ranging from equal values of proportions (e.g., 2/11 and 3/11), proportions with simple multiplication (e.g., 11/20 and 22/36) or complete calculation. In missing value problems one value in one of two proportions is missing. Learners have to find this "missing value" in order to ensure that both proportions are equal. Transformation problems involve two proportions as well and all values are known, but the proportions are not equal. Learners have to find out how much has to be added to one or more of the proportions in order to make both proportions equal (for a more extensive description see Vandercruysse et al, 2014). Both missing value and transformation problems can be classified in one of four difficulty levels based on the integrity of the ratio within (comparing the same term of two proportions) or between (comparing the different terms of the proportions) two proportions. For example, a problem with 1/2 and 3/6 can be classified as level 1 (easy) because both the ratio within (in this case 1 and 3, or 2 and 6) and the between ratio (in this case 1 and 2, or 3 and 6) are integer.

2.3.2 Game environment

In the 2D game – developed in Flash/ActionScript 3 - players have a summer job in a hotel. By doing different tasks the players can earn money that can be used to select a holiday destination during the game: the more money they earn, the further they can travel. During the game the player is accompanied by the manager, a non-playing character, who provides information about the task and gives feedback regarding the performance on the task. The game comprises a base game and several subgames. The base game provides the structure from which the subgames can be started. After selecting an avatar, the players receive an introduction animation in which the context of the game is presented, and finally enter the "Student room" from which the player can control the game (e.g., for example by choosing a specific subgame). Each task is implemented as a subgame and covers a specific problem type in the domain of proportional reasoning. The tasks are directly related to proportional reasoning (e.g., mixing two drinks to make a cocktail according to a particular ratio directly involves proportional reasoning skills). In addition, mental operations with respect to proportional reasoning are connected with the game mechanics (e.g., in order to get the correct amount of bottles in the refrigerator the player has to drag the correct number of bottles in the refrigerator). Table 1 shows the subgames and the distribution of difficulty levels across the game levels.

Although the subgames cover different problem types, they have several common elements. The actual assignment is described on a *whiteboard*. With drag-and-drop or clicking the player can accomplish the assignment, but the specific action depends on the subgame. To further motivate the player, a *"geldmeter" (money meter)* is implemented which visualizes the amount of money that the player will receive after an assignment. Correct and incorrect actions during an assignment are directly reflected in the money meter. For example, if the player breaks a bottle, the money meter will decrease (and the color becomes redder); if the player places bottles in the refrigerator the money meter will increase (and becomes greener). The money meter also shows the (accumulated) amount of money that the player has earned. The player can use a built-in *calculator*, but using it will cost some money. Depending on the subgame, the player has to perform a typical action (e.g., closing the door of the refrigerator) to receive *verbal feedback* from the manager of the hotel who tells whether the answer is correct or not (e.g., 'Excellent' or 'You have too much Cola in relation to Fanta'). If the answer is correct the money meter will be increased.

Surprise comprised a non-playing niece character in the introduction animation who tells she is bored. When a surprising event occurred, the screen first became bright and then normal again, the niece character popped up and told that she had changed something. This change comprised specific characteristics of the task whereby the solution of the player doesn't apply anymore and the player has to reconsider the original solution. Figure 1 gives an example of the occurrence of a surprise.

Table 1: Overview of level structure per subgame

Subgame	Problem type	Example of problem	Game level: difficulty of proportional problem
Jugs	Comparison	"There are two jugs of juice on the counter. A customer asks for the sweetest juice mix. Which juice mix will you give to the customer?" The ratio of water/fruit is presented on the jugs. The student has to click on the correct jug to answer.	1: contains level 1 problems 2: contains level 2 problems 3: contains level 3 problems 4: contains a mix of all levels
Fridge	Missing value	"This is the reception desk refrigerator. This refrigerator always contains 3 bottles of water for every bottle of juice. It already contains 9 bottles of water. Fill the refrigerator so it will contain the right amount of juice." The given ratio of 3/1 is presented next to the ratio with the missing value 9/?. The student has to answer the question by dragging and dropping the juice bottles into the refrigerator.	1: contains level 1 problems 2: contains level 2 and 3 problems 3: contains level 4 problems 4: contains a mix of all levels
Blender	Transformation	"A fruit cocktail contains 10 berries for every 100 ml of yoghurt. How many berries should you add to 500 ml of yoghurt if you want to maintain the flavor?" The given ratio of 10/100 is presented and the student has to answer the question by dragging and dropping the berries into a blender that contained the 500 ml of yoghurt.	1: contains level 1 problems 2: contains level 2 and 3 problems 3: contains level 4 problems 4: contains a mix of all levels

Figure 1a depicts the starting situation. The solution strategy of the player can be as follows: the number of Fanta in the refrigerator is twice as much as the number of Fanta in the desired proportion (12 Fanta) since 12 * 2 =24, so the number of Cola also has to be doubled (9 * 2 = 18 Ccola). When the player is implementing the solution the surprising event occurs (Figure 1b). When the niece character has disappeared the characteristics of the task are modified (Figure 1c), that is, the desired proportion is now 6 Cola per 12 Fanta. In total the players received 8 surprises (four in both the missing value and the transformation subgames).

Figure 1a: Starting situation in a task with a surprising event

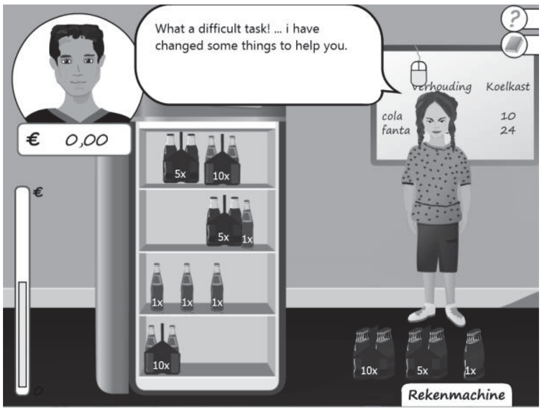

Figure 1b: Occurrence of the surprising event

Figure 1c: Task characteristics have been modified

For the implementation of Expectancy strength, we classified the problems according to their characteristics into three groups

- Problems with an integer intern ratio but not an integer extern ratio
- Problems with an integer extern ratio but not an integer intern ratio
- Problems have neither an integer extern ratio nor an integer intern ratio

We defined strong expectancy as a series of problems with the same characteristics (e.g., 3 problems from group 1). Weak expectancy was defined as a series of problems in which the characteristics varied.

In all conditions the players received three levels with five problems in each level, but the distribution of problems with specific problem characteristics was different.

2.3.3 Tests

The arithmetic tempo test, the TTR (Tempo Test Rekenen), measures the degree of fluency in basic arithmetic operations i.e., addition, subtraction, multiplication, and division (de Vos, 1992). For each operation there is a column with 40 arithmetic problems (so four columns in total). A fifth column contains problems with mixed operations. The students have one minute per column to solve as many arithmetic problems as possible.

Proportional reasoning skill was measured with 12 open questions: 4 questions for each problem type. The questions were comparable with the assignments in the game. An example (missing value) is:

> *"For a banana milkshake you have to use 28 bananas and 48 units of ice. How many units of ice do you need if you are going to use 56 bananas and you want to remain the same proportion?"*

There were two versions of the test. The structure of these versions was the same, but the numbers were different. The comparability of both versions was tested in pilot study.

2.4 Procedure

The experiment was run on the computers of the schools. The experiment took 150 minutes divided into three sessions of 50 minutes. In the first session the experiment was introduced and the pre-test was administered (40 minutes). When participants had finished the pre-test they could do their homework. In the second session, a week later, the participants played the game (40 minutes). At the beginning of the session the participants were seated at a designated computer and received a login code. All actions of the players during playing the game were logged. The post-test was administered in the third session (40 minutes, a week after playing the game). One version was used in the pre-test, the other version in the post-test.

2.5 Scoring

TTR. The TTR score is calculated as the sum of correct answers in the five columns. The range of possible scores is 0 – 200.

Skill test. Each answer of the pre-test and post-test was coded as 0 (wrong answer or no answer) or 1 (correct answer). For the analysis we focused on the performance on the three problem types (4 questions each) and on the overall performance (12 questions).

3. Results

An ANOVA with posthoc analysis revealed no differences in prior knowledge between the conditions. To test hypothesis 1 we conducted a paired samples T-test. The results show that playing the game improves learning ($t(93) = 2.39$, $p = .019$, $d = .25$). To test the effect of Surprise and Expectancy we looked separately to the surprise items consisting of the two problem types in which these factors were applied (missing value- Refrigerator sub game and transformation - Blender subgame) and the items for the comparison problem type (Jugs subgame). The results are shown in Table 2. A 2*2 ANCOVA was conducted with Surprise and Expectancy strength as independent variables, posttest score as dependent variable and TTR and pretest scores as covariates.

Table 2: Mean scores and standard deviations on the dependent variable for all conditions

	Surprising events				**No surprising events**			
	Strong expectancy		Weak expectancy		Strong expectancy		Weak expectancy	
TTR	118 (30)		130 (20)		121 (27)		124 (31)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
All items	5.71 (2.34)	6.90 (3.18)	6.00 (3.05)	6.95 (3.29)	5.07 (2.41)	5.53 (3.46)	5.56 (1.61)	5.86 (3.16)
Surprise items	3.04 (1.88)	4.28 (2.23)	4.00 (2.41)	4.79 (2.53)	3.11 (2.41)	3.57 (2.14)	3.21 (1.44)	3.47 (2.44)
Comparison	2.66 (1.06)	2.61 (.97)	2.00 (1.06)	2.17 (1.20)	1.96 (.95)	1.96 (1.18)	2.35 (1.07)	2.39 (1.40)

Note: Range of all items is 0 to 12. All items means all proportional reasoning skill items. Surprise items (are missing value and transformation items) range is 0-8. Range comparison is 0-4.

For the surprise items we found a marginally significant main effect for Surprise ($F(1, 90) = 3.161$, $p = .079$). The main effect for Expectancy strength and the Surprise*Expectancy strength interaction were not significant (both $F(1, 90) < 1$). For the comparison items we did not find main or interaction effects (all $F < 1$).

The participants in this study represent a heterogeneous population which is reflected in the large SD, in each condition there are large differences. We assumed that better performing students would possess the (meta)cognitive skills to deal with the surprises and benefit from the cognitive processes that they trigger. We divided the sample in low and high level students based on the median score of 6 on the pretest. Figure 2 shows the posttest scores on the surprise items for low and high level students. We ran an ANCOVA with the posttest score on the surprise items as dependent variable; surprise, expectancy strength and level as fixed factors and TTR as covariate.

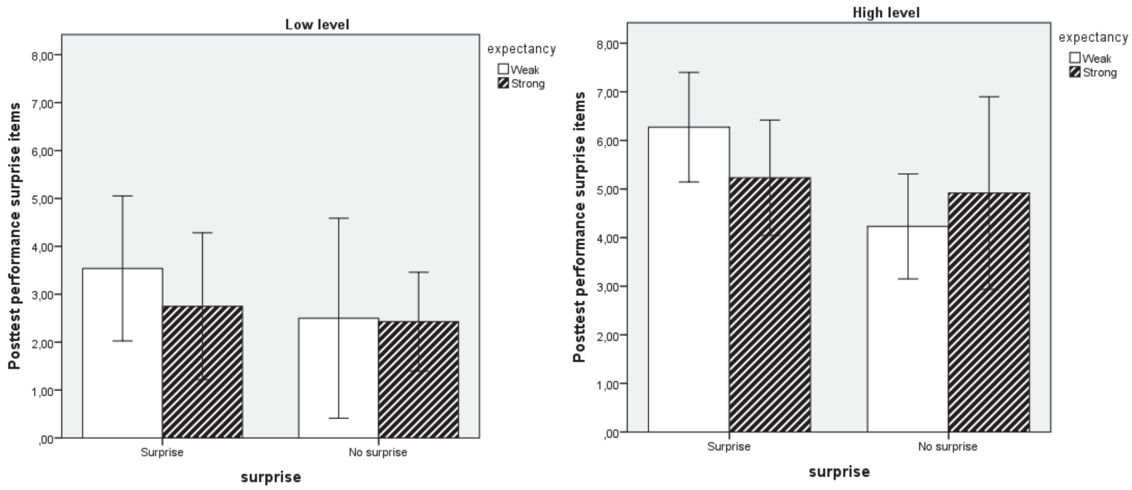

Figure 2: Post performance on surprise items (missing value and Transformation) for low (left) and high (right) level students

We expected to see an interaction between surprise and level, indicating that high level students would benefit more of surprises than low level students. The results, however, only show significant main effects for Surprise ($F(1, 85) = 4.120$, $p = .046$) and Level ($F(1, 85) = 18.980$, $p = .001$), but all other main or interaction effects were not significant (Expectancy*Surprise: $F(1, 90) = 1.057$, $p > .05$; all other effects $F < 1$).

4. Conclusion and discussion

We found that learning improves by playing the game. This corroborates earlier findings regarding serious games in general (cf. Wouters et al., 2013) and other studies with the game Zeldenrust (ter Vrugte et al., in press). An important precondition for effective surprise is that players have sufficient cognitive flexibility and metacognitive skills to orientate on the task, to re-evaluate the results at the moment when the surprise occurs and to reflect on the performed actions. Earlier we found indications that surprise hampered learning for learners with a low educational level, while it seemed that high educational level learners benefitted more from these events (Wouters et al., 2015). In the current experiment we only used high educational level students. We found a marginal effect of surprise on learning indicating that students who experienced surprises learned more than students who were not exposed to these surprises but we found a stronger effect of surprise when we included existing proportional reasoning skill as factor. These results connect with other studies that find cognitive effects of narrative techniques (e.g., surprise, curiosity, suspense) in games (van der Spek et al., 2013; Wouters, van Oostendorp, Boonekamp, & van der Spek, 2011). These results imply that instructional techniques such as surprises should be applied with care. Students with sufficient (meta)cognitive capabilities can handle surprises in complex learning environments such as computer games, students who lack these competencies can be overwhelmed by the additional cognitive demands that are introduced by these surprises. More research is required to investigate the robustness of the surprise effect and the underlying cognitive mechanisms. Possibly, the effect of surprise can be increased by offering students additional instructional support during the problems before the surprise intervention occurs which may help them to select an appropriate method for a problem. One could think of exercises that help them to automatize part-tasks such as multiplication tables so that they can more easily identify intern or extern ratios and/or worked examples in which strategies for specific types of problems are modelled.

Two other lines of research can be interesting. First, there is some evidence that metacognitive skills in math improve with small differences in age (van der Stel et al., 2010). The students in this study had a mean age of 13.9 years (second year class) and the metacognitive skills of some may have been insufficiently developed. Another point is that the students come from the least advanced of three Dutch educational tracks in which students are prepared for intermediate vocational education. It would be interesting to replicate this study with older students in the same educational level (third or fourth year class) or students from a higher educational track. A second research avenue pertains to the characteristics of the game. The game Zeldenrust has a repetitive character, students engage in the same type of tasks which require similar actions. It is not unlikely that students finally will expect that the niece character will reappear and modify the nature of the task. In that case they may anticipate these events and thus undermine the potential effect of surprise. If that is the case more variation in surprise can perhaps further increase their effectiveness.

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PhD Research Papers

Pre-Test Session Impact on the Effectiveness Assessment of a Fire Safety Game

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Abstract: In recent years, critiques have been formulated regarding current evaluation methods of DGBL (digital game-based learning) effectiveness, putting the validity of certain results in doubt. An important point of discussion in DGBL effectiveness studies is whether or not a pre-test should be administered, as it can lead to practice effects and pre-test sensitization, threatening internal validity of the results. The present study aims at testing if the administration of a pre-test has a direct influence on post-test scores and/or makes participants more receptive to the intervention. For this purpose, an effectiveness study of a fire safety training in a hospital was conducted using a Solomon four-group design. The experimental groups received a game-based intervention (n= 65) of which 34 participants received a pre-test and 31 did not. The control groups received traditional classroom instruction (n=68), of which 39 participants received a pre-test and 29 did not. A 2x2 ANOVA was used to explore the practice effect and the interaction between the pre-test and the intervention. An interaction effect between pre-test and intervention is detected. More specifically, this interaction takes place in the traditional classroom group, indicating pre-test sensitization. In the traditional classroom context, the pre-test makes the participants more sensitive to the content treated in the intervention while administration of a pre-test does not influence outcomes of the DGBL treatment. When the administration of a pre-test influences the control group's receptivity to the treatment, but not the experimental group, results of an effectiveness study may be biased. This is especially relevant in the DGBL field as often, non-significant differences between DGBL and more traditional methods are reported. Therefore, further research should take this into account and look for possible solutions to solve this discrepancy.

Keywords: DGBL, pre-test sensitization, practice effect, Solomon 4-group design, fire safety

1. Introduction

The interest in using digital games as instructional tools for digital game-based learning (DGBL) has increased over the past decade. DGBL has been implemented in different sectors, such as defense, education, corporate training, health and wellbeing, and communication (Backlund & Hendrix, 2013). Whilst in recent years, there has been a significant increase in publications on the effectiveness of DGBL (Hwang & Wu, 2012), certain methodological issues remain a matter of debate in this field (Bellotti et al. 2013; Giessen 2015).

For instance, there is a large heterogeneity in study designs which makes the comparison of results across DGBL studies difficult (All, Nuñez Castellar & Van Looy 2014). By heterogeneity we mean that research designs differ on several respects, such as implementation of a control group, activities implemented in the control group(s) or the administration of a pre-test (Hays, 2005; Michael & Chen, 2005). Furthermore, studies are frequently being implemented without a strict control of potential threats to their internal validity, such as the addition of training materials to the intervention (e.g., required reading, exercises) or the lack of a standardized protocol for instructors (e.g., procedural help, guidance only during the intervention). Moreover, authors often fail to mention whether or not self-developed tests have been piloted, which leads to doubts with regard to the reliability and validity of results (Brom, Šisler, Buchtová, Klement, & Levčík, 2012). Furthermore, another important methodological issue that deserves attention is that it is difficult to replicate published DGBL effectiveness studies given that authors often do not provide enough information on how the intervention -both the experimental and control condition- has been implemented (All, Nuñez Castellar & Van Looy, 2014). Detailed information on procedure is indispensable, however, in order to assess whether the gains that are reported are a consequence of the different methods and not due to other circumstantial factors that differed between conditions (Randel, Morris, Wetzel, & Whitehill, 1992).

Considering these methodological limitations, a more systematic approach that can serve as a guideline for quality assessment is required for researchers willing to conduct effectiveness studies in this field (Mayer et al. 2014). For this purpose, research into preferred research designs is required.

1.1 Pre-test administration

An important point of discussion is whether or not a pre-test, gauging for baseline measures of knowledge, should be administered. The addition of a pre-test to the research design is advantageous as it allows researchers to control for pre-existing differences between the experimental (game-intervention) and control group (traditional intervention) (Clark 2007) and to compare progress (i.e., gain scores) as a result of the intervention implemented (Gerber and Green 2012). Moreover, a more precise estimate of the treatment effect is allowed by adding the pre-test as a covariate, controlling for individual differences on the pre-test scores (Jamieson 2004; Knapp and Schafer 2009). Lastly, the addition of a pre-test allows the researcher to control for characteristics of drop-outs (All et al. 2014). However, adding a pre-test can also 'blur' the real effect of the treatment. Firstly, administering a pre-test can result in 'practice effect', meaning that subjects that take the same test twice, do automatically better the second time, even if the intervention would not have taken place (Crawford et al. 1989). This is thus the main effect of the pre-test, as it can offer participants additional exercise material, item training or a search strategy (van Engelenburg 1999). Hence, progress due to the intervention and progress due to the practice effect cannot be isolated from each other. Moreover, pre-test sensitization can occur, referring to an interaction effect of the pre-test and the treatment (Braver and Braver 1988; van Engelenburg 1999). This means that subjects who have received a pre-test will be more sensitive to the intervention compared to subjects who have not received a pre-test, resulting in higher scores on the post-test. Hence, one cannot know whether a positive effect as a result of the treatment would have been present if a pre-test was not administered. Hence, generalization of results from a pre-tested to an unpretested sample is prevented. This has resulted in researchers renouncing a pre-test when studying effectiveness of DGBL (Amory 2010; Tsai et al. 2012). However, pre-test influences have -to our knowledge- never been studied in a DGBL context. Therefore, before making assumptions on the absence of a pre-test effect or pretest sensitization, this needs to be studied (Braver and Braver 1988).

An experimental design that is proposed to investigate the issues of practice effects and pre-test sensitization, is the Solomon four group design (Solomon 1949). In this design, four conditions are present: the first two conditions are the same as in the classic pretest-posttest design: participants receive a pretest, an intervention is implemented and a post-test is administered. The two extra conditions parallel the treatment and control condition, but a pre-test is absent (see table 1).

Table 1: Solomon four group design

Condition	Pre-test	Intervention	Post-test
Treatment condition 1	Yes (O1)	X	Yes (O2)
Control condition 1	Yes (O3)	C	Yes (04)
Treatment condition 2	No	X	Yes (05)
Control condition 2	No	C	Yes (06)

The present study aims at looking at pre-test influences in a DGBL effectiveness research context. More specifically, we aim at testing for a main effect of pre-test (i.e., pre-test effect) and an interaction effect between pre-test and treatment (i.e., pre-test sensitization).

2. Method

2.1 Design

A Solomon four-group design was implemented in order to assess the effectiveness of a digital game-based fire safety training among hospital personnel. Participants in the experimental condition received a digital game-based intervention and participants in the control group received the traditional PowerPoint lecture. Randomization of subjects was not possible in this study, as the traditional lecture takes place once a month and staff already subscribed for these courses. Consequently, the groups that were formed as a result of these subscriptions were randomly assigned to either the condition with or without pre-test. During the period of the intervention, the prevention manager of the hospital organized ‘extra safety training sessions’ for which hospital staff could subscribe. These were also randomly assigned on a group level (i.e., a group was composed of people that subscribed for a safety training on the same date; similar to how groups are composed in the traditional lecture groups) to either the game condition with or without a pre-test.

2.2 Stimulus material

2.2.1 Digital game-based fire safety training

The DGBL fire safety training was specially developed for the hospital of which personnel participated in the study. All hospital personnel (i.e., doctors, nurses, cleaning personnel, administrative staff, technical staff, etc.) is required to follow the fire safety training every year. However, because the hospital has expanded over the years and is still expanding -a fourth campus has recently been built- organizationally, it is becoming more difficult to provide everyone this training. Hence, the decision to develop a digital game in cooperation with <removed for the blind review process>. The game consists of three minigames or courses: ‘small fire’; ‘smoke’ and ‘blaze’. After these courses are completed, one can also play a random ‘fire safety’ scenario, where elements learned in the course can be practiced. In total, 6 different scenarios are available.

2.2.2 PowerPoint

The PowerPoint lecture is instructed by either the prevention manager or another fixed employee working at the department prevention. This is the lecture that is currently being used as a fire safety training for the hospital personnel. This lecture was also used as a base to define content treated in the game and contains exactly the same content as treated in the game.

2.3 Procedure

2.3.1 Experimental groups

The experimental groups played the game in a conference room in one of the four campuses of the hospital, during their working hours. A maximum of six subjects could participate per session. When entering the conference room, subjects received an introduction with information regarding the purpose of the study. Afterwards, the subjects either filled out the pre-test (experimental condition with pre-test) or started playing the game (experimental condition without pre-test).

The subjects played the game individually on a laptop computer with a headphone. During game play, two researchers were present providing procedural help, meaning that help was only provided if there were issues with the computer or game play. After the subjects completed all three courses and one scenario, a pre-test was administered. A maximum of 6 participants could take part in a game based fire safety training session. In total, 18 game training sessions were organized; 9 included a pre-test and 9 did not.

2.3.2 Control groups

The control groups received the PowerPoint lecture in a conference room in one of the four campuses. The PowerPoint lecture was instructed by either the prevention manager or another fixed employee from the prevention staff that was responsible for the fire safety training. The same procedures were followed regarding administration of the pre-test and post-test as in the experimental groups. The subjects were instructed in groups of minimum 8 and maximum 20 people. In total, 6 PowerPoint lectures were organized, 3 included a pre-test and 3 did not.

2.4 Participants

The present study was in collaboration with a hospital in <location removed for blind review process>. In total, 152 subjects participated in the study. Eighty tree subjects participated in the experimental groups, of which 42 subjects received a pre-test and 41 did not receive a pre-test. Sixty-nine subjects participated in the control groups of which 39 received a pre-test and 30 did not receive a pre-test. Eighteen subjects in the experimental group (8 that received a pre-test and 10 that did not receive a pre-test) were excluded from the analysis, because log data showed that they either did not complete all three courses or they repeated a course several times. In the end, 134 participants were included in the analysis.

As can be seen in table 2 provides, randomization on a group level has led to a balanced group in terms of age and proportion of gamers, but not in terms of gender proportion.

Table 2: Control for balanced groups as a result of randomization on group level

	Experimental group with pre-test (n=34)	**Experimental group without pre-test** (n=31)	**Control group with pre-test** (n=39)	**Control group without pre-test** (n=29)	**Chi²/F**	**p**
Female gender	76.50%	71.00%	92.30%	96.60%	10.87	0.01
Age (mean)	40.03	37.52	38.31	40.83	0.54	0.66
Gamers	50.00%	61.30%	61.50%	48.10%	2.00	0.57

2.5 Measures

2.5.1 Cognitive learning outcomes

In order to assess knowledge a test was developed by the researchers in cooperation with the prevention staff responsible for the fire safety training –the same staff that provides the PowerPoint lectures. The test was previously implemented in a pilot study in an initial phase of development of the game. The test consists of open ended questions, covering all learning elements that are treated in both interventions. The test consists of 18 questions with a maximum score of 40. Examples of questions are*: What is the first step you have to take when a small fire breaks out? How do you do this? What are the three steps to follow when evacuating patients? Which tree steps do you have to take to evacuate a bedridden patient? Etc.* The tests were corrected by two researchers. For this purpose, an evaluation form was developed in order to guarantee a standardized manner of correcting the tests. If there was doubt on the correctness of certain answers, researchers consulted each other to agree upon a score.

2.5.2 Motivational outcomes

The IMMS -Instructional Materials Motivation Survey- (Keller 1987) was used to assess motivation towards the instruction method. We based ourselves on (Huang et al. 2010) for the game version of the IMMS. The IMMS consists of 36 items, divided in 4 subscales: attention (i.e., gaining and keeping the learner's attention), relevance (i.e., activities must relate to current situation or to them personally), confidence/challenge (i.e., activities cannot be perceived as too hard or too easy, which is also a prerequisite for an optimal game experience or game flow) and satisfaction/success (i.e., learners must attain some type of satisfaction or reward from the learning experience). The items are scored on a 5-point Likert scale. The total score represents motivation towards the instructional material. The scores on the subscales give an indication on which elements the instruction failed, based on the subcomponents (Keller 2010). Enjoyment was assessed by using Ryan & Deci's (Ryan 1982) enjoyment/interest scale from the post-experimental intrinsic motivation inventory. The scale consists of 8 items which are scored on a are scored on a 7-point Likert scale. Interest was assessed by the social facilitation subscale of the subjective involvement scale developed by by Neys & Jansz (2010). This scale consists of 3 items aims at assessing the desire to interact with others about the topic discussed in the game and consists of 3 items. The items were scored on a 7-point Likert scale. We, however, do not discuss the motivational outcomes of the present study, as space is limited and the aim of the paper is to assess the impact of the pre-test and motivational outcomes -in this case- can only be assessed post-intervention.

3. Results

3.1 Effectiveness of the DGBL treatment

We firstly conducted an analysis on the groups receiving a pre-test (N=73), in order to determine progress (pre-test vs. post-test scores) and compare progress between groups (DGBL vs. PowerPoint lecture). A paired sampled t-test showed a significant difference between pre-test and post-test scores for both the participants receiving a PowerPoint lecture, $t(33)= 9.45$, $p < 0.01$ and the participants in the DGBL intervention $t(38)=12.78$, $p < 0.01$, showing that both the DGBL training as the PowerPoint lecture entail a learning effect. Since the post-test scores

were not normally distributed, we conducted the analysis on transformed data (square root transformation)(Kutner et al. 2005).
In order to compare whether or not this progress is different across groups, we first checked for pre-existing differences by conducting an ANOVA with pre-test as dependent and instruction method as independent variable. Results show that the DGBL group scores significantly higher on the pre-test than the group that received a PowerPoint lecture, F(1,71)=20.31, p < 0.01. Hence, we need to take these pre-existing differences in our analysis by adding pre-test scores as covariates (Jamieson 2004).

We used a difference-in-difference approach for our data-analysis (Gerber and Green 2012), creating a new variable 'gainscore' by subtracting the pre-test scores from the post-test scores. An ANCOVA was conducted with gainscore as dependent variable, instruction type as independent variable and pre-test scores as a covariate, to control for initial differences (Jamieson 2004). Results show that after controlling for initial differences, instruction type has a significant effect on the game scores. In figure 1 (reflection of untransformed data), we see that the DGBL group shows significantly higher gain than the group that received a PowerPoint lecture, F(1,79)=10,76, p < 0.01. Note that if we would not have controlled for these initial differences on pre-test, no effect of instruction type would have been found, F(1,79)=0.02, p=0.88.

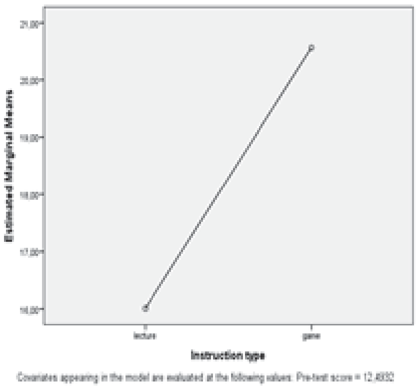

Figure 1: Line plot of mean gain score

3.2 Effect of the pre-test

Considering that there are no clear guidelines on the types of analyses to conduct when implementing a Solomon 4-group design when pre-existing differences exist between experimental and control group that received a pre-test, we will conduct our analysis twice: one with the complete data set (i.e., including individual differences) and one where we have matched participants that received a pre-test on their pre-test scores (N= 102)

3.2.1 Analysis on complete dataset

In order to assess the influence of the pre-test on both the post-test and the treatment, we conducted a 2x2 ANOVA. The two independent factors where the administration of a pre-test (two levels: pre-test was administered or no pre-test was administered) and the instruction type (two levels: DGBL or PowerPoint lecture). The dependent variable was post-test scores. Considering that the assumption on normality was violated and the data were negatively skewed, we conducted the analysis on transformed data (square root transformation) (Kutner et al. 2005). All statistics below are based on the transformed data, but the graphs reflect the untransformed data.

Results show that there is a main effect of instruction type F(3,147)=10.19, p < 0.01. More specifically, the participants that received the DGBL intervention scored significantly higher on the post-test.

There is no main effect of administrating a pre-test on the post-test scores F(3,15)=3.44, p < 0.06, but that the interaction between pre-test and instruction type is significant F(3,15)=10.19, p < 0.01. In fig. 2, we see that the influence of the pre-test on the treatment is larger in the group that received a PowerPoint lecture than in the group that received a DGBL intervention.

When we compare post-test scores of the four groups using an ANOVA with the grouping variable (four levels: DGBL with pre-test, DGBL without pre-test, PowerPoint Lecture with pre-test and PowerPoint Lecture without pre-test), a post-hoc Scheffé test shows that no significant differences can be found between the DGBL intervention group that received a pre-test and the DGBL intervention group that did not receive a pre-test, $F(3,13)=47.44$, $p=0.99$. A significant difference is detected between the PowerPoint lecture groups that did receive a pre-test and those that did not ($p < 0.01$). More specifically, the group that received a pre-test before receiving the PowerPoint lecture, scores significantly higher than the group that did not receive a pre-test before the PowerPoint lecture. This indicates that administering a pre-test influences the participants' sensitives to receiving the fire safety training with a PowerPoint Lecture, but not when receiving the training by playing the game.

Both gaming groups still score significantly higher on the post-test scores compared to the PowerPoint groups, indicating that the game is more effective in terms of knowledge transfer than the PowerPoint lecture.

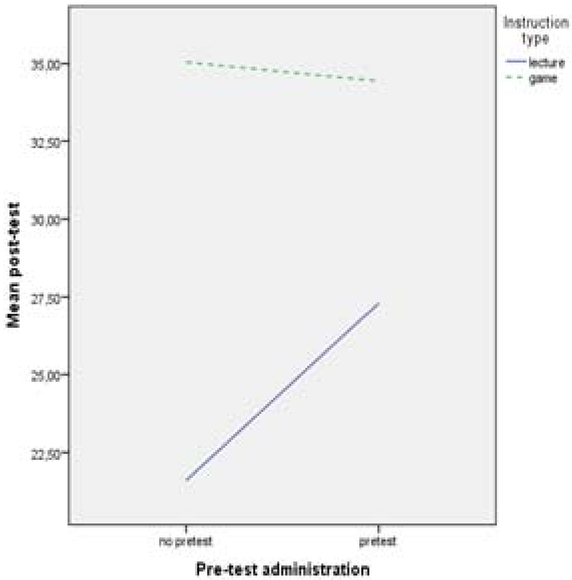

Figure 2: Line plot of mean post-test scores (N=134)

3.2.2 Analysis on matched groups

Matched groups were constructed for the participants that received a pre-test, by looking for participants in the DGBL and the PowerPoint lecture group that have a similar score (i.e., maximum 1 point difference). In the end, 21 participants remained in both the DGBL and PowerPoint group that received a pre-test. No significant differences were found on pre-test scores between the new composed experimental an control groups receiving a pre-test, $F(1,40) = 0.02$, $p = 0.82$. Since the other groups did not receive a pre-test, we could not match them based on pre-test scores and thus left them unmodified. The present analysis was conducted on a sample of 102 participants.

In order to test for pre-test influences, we conducted the same 2X2 ANOVA as discussed in 3.2.1. In line with the results on the complete dataset, we find a significant main effect of instruction type, in favor of the DGBL intervention, $F(3,98)=69.33$, $p < 0.01$. No significant main effect of pre-test is found, $F(3,98)=2.97$, $p = 0.09$ and a significant interaction between instruction type and pre-test administration is detected, $F(3,98) =16.99$, $p < 0.01$. When we take a look at the graph, we again see that the influence of the pre-test on the treatment is larger in the group that received a PowerPoint lecture than in the group that received a DGBL intervention.

When conducting an ANOVA on the post-test scores of the 4 groups, a post-hoc Scheffé test shows that there is no significant difference between the post-test scores in the DGBL training group between participants that received a pre-test and those that did not $F(3,98)=34.61$, $p=0.41$. A significant difference can, however, be found between groups receiving PowerPoint instruction that were administered a pre-test before the lecture and those that were not. More specifically, the group that received a pre-test before the PowerPoint lecture scored significantly higher on the post-test than participants that did not receive a pre-test before the PowerPoint Lecture.

The game groups outperformed both PowerPoint groups, indicating that the game is more effective in teaching the fire safety training to the hospital personnel than the PowerPoint lecture.

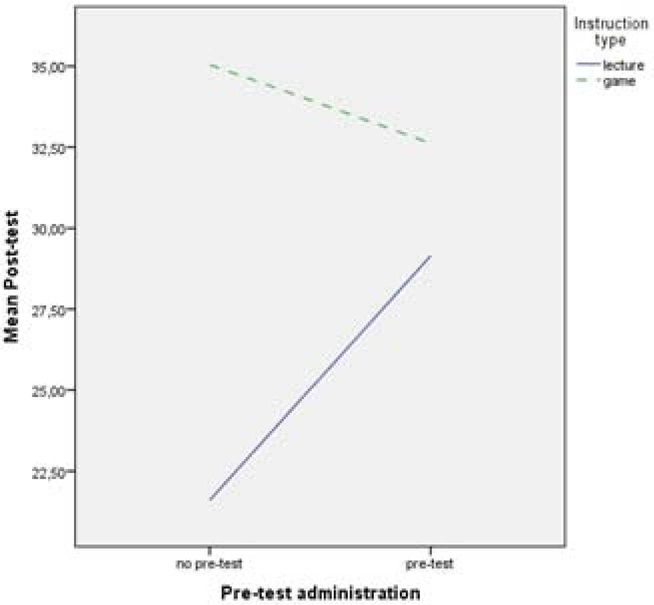

Figure 3: Line plot of mean post-test scores (N=102)

4. Discussion and conclusion

The present study has for the first time -to our knowledge- conducted a Solomon four group design in the context of DGBL. Our results revealed that the pre-test influence on an educational intervention depends on the type of instruction that is administered. More specifically, pre-test sensitization was found when receiving the traditional PowerPoint lecture, but not when receiving the DGBL intervention. Participants receiving a pre-test before receiving a PowerPoint lecture on fire safety were thus more sensitive to the intervention and consequently, scored significantly higher on the post-test than participants that did not receive a pre-test before the PowerPoint lecture. Providing a pre-test to participants receiving DGBL intervention did not result in higher scores on the post-test compared to participants that did not receive a pre-test before the DGBL fire safety training.

When receptivity to an intervention is altered due to the pre-test in one group and not in the group to which it is compared to, bias is introduced in the design (McCambridge et al. 2011). This is an important implication for the DGBL research field, as effectiveness studies on DGBL often show non-significant differences compared to traditional instruction (Giessen 2015). In pre-test post-test designs this can lead to issues regarding internal validity, as post-test scores in control groups receiving traditional instruction might be significantly elevated by the administration of the pre-test while the scores in the DGBL treatment represent the 'true' scores as a result of the instruction itself. This non-significant difference might have been significant in favor of DGBL when no pre-test sensitization would have occurred in traditional lecture. This makes comparison of post-test scores as a result of different instruction methods rather difficult.

In the present study, the game groups still outperformed both the control group receiving a pre-test and the control that did not receive a pre-test, concluding that the DGBL fire safety training was highly effective.

The present study has also shown the advantages of adding a pre-test, indicating pre-existing differences between experimental and control group. This way, when looking into the effectiveness of the DGBL treatment, we could control for these initial differences by adding pre-test scores as a covariate (Jamieson 2004; Knapp and Schafer 2009). If we would not have been able to control for initial differences, no significant differences would have been found when comparing the progress of the PowerPoint lecture and the DGBL group.

Considering the advantages and disadvantages of the administration of a pre-test as described above, we have several recommendations for researchers aiming at assessing the effectiveness of DGBL. Firstly, pre-tests should be administered but time between pre- and post-test should be increased, minimizing the influence of the pre-test (Dochy et al. 1999). This also gives researchers the opportunity to match participants in experimental and control group, based on the pre-test scores (Gerber and Green 2012). Secondly, we recommend using parallel tests pre- and post- interventions (i.e., same types of questions and same difficulty level). These tests should be piloted beforehand, in order to check whether or not these tests can be perceived as parallel versions. A good example can be found in a study conducted by Nuñez Castellar and colleagues (2013). Thirdly, we recommend researchers to not only report on differences between groups regarding progress (i.e., gain scores), but also on post-test scores, in order to provide a more complete understanding of the data, as these can yield different results (Knapp and Schafer 2009).

5. Limitations and further research

Further research implementing the Solomon design is required, as there were pre-existing difference between the experimental and control group in the pre-tested groups. This keeps us in doubt about the similarity of the experimental and control groups in the unpretested groups regarding prior knowledge on fire safety, possibly influencing our results. Hence, further validation of our results is required.

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Learning Between Rules and Narrative: Player's Meaning Negotiations Analyzed, Designed and Assessed

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Abstract: It has been recently noted that there is a special need for research on the particulars of learning and serious game design. The aim of this study is to examine how mutually different learning objectives, game narrative design, and game rules can be combined by various ways. There can be multiple roles for the player in narrative serious and learning games, including the roles of the game player, learner, narrator, or story character. Depending on design decisions of a game at issue, the player may be moving between different roles during the game playing and as an intentional actor s/he has to conduct multiple meaning negotiations between different types of game rules and narrative elements perceived during the game playing. The player's role and the abovementioned operations are discussed in this article as *co-storyliner's meaning negotiations*. It is assumed that, in narratively rich games, the design decisions governing the co-storyliner's meaning negotiations play a central role regarding what is finally to be learned through the game playing. The author proposes an analysis and design framework called *the Design Space for Instructional Game Narrative* (DSIGN), which helps researchers specify and hermeneutically analyze the design space between various types of game rules and semiotic-cognitive areas of narrative design. Thereby, the mechanisms by which various games create meanings can be understood more closely and compared to the explicitly stated learning objectives of the games. The utilization of the framework is demonstrated by presenting brief learning game analyses using a hermeneutic approach, which highlights player's interpretations, or *readings*, of game and narrative-related representations and situations. The presented analyses illustrate how the applied framework can aid to specify the potential-based design by which the player-learner's cognitive processes are aimed to be steered through the crossroads of game narrative and rules. For conclusions, it is discussed how the DSIGN model could be applied as a guiding tool for serious and learning game design and assessment.

Keywords: narrative, game rules, learning, serious game design

1. Introduction

It has been recently noted on the field of serious game research that *how*-oriented questions focusing on game design are especially necessary (Clark, Tanner-Smith and Killingsworth 2014). The focus of this article is on how game narrative design can intersect with game rules, and thereby affect the player's process of constructing meanings during the game playing. Even if some previous studies consider instructional potentials in the *game narrative* design (for example, Dickey 2006 on adventure games), in educational or instructional context narrative is mainly considered as in traditional storytelling media forms.

In the present study, it is assumed that in story-driven game genres high-quality narrative design supports the inherent learning of game playing. This could be achieved by creating meaningful links between different game rules and the areas of narrative design. I am going to describe a model called *the Design Space for Instructional Game Narrative* (DSIGN), by which I specify the possibilities to create such linkages, and thereby support player's learning through game narrative design. I am going to present samples from broader analyses, which focused on award-winning narrative learning games, namely *Global Conflicts: El Patron*, *Mission US: A Cheyenne Odyssey* and *School of Dragon* (more information about the awards of the games can be found from their respective homepages).

In each three example games, *Global Conflicts: El Patron* (*GC:EP*), *Mission US: A Cheyenne Odyssey* (*MUS:ACO*), and *School of Dragon* (*SoD*), the explicitly declared learning object concerns enhancing students' understanding on complicated topics, such as historical knowledge (*MUS:ACO* and *GC:EP*), abstract phenomena of social sciences, such as international affairs, corruption, and social inequity (*GC:EP*), or subjects of sciences, such as motion and forces (physical science), ecosystem (life science), and water system (earth science). The learning objectives include factual and conceptual knowledge. Besides, all the three games set a learning objective of understanding and applying some procedural knowledge, such as successfully implementing scientific method and conducting scientific experiments (*SoD*), successfully applying interview skills and principles (*GC:EP*), developing and applying historical empathy (*MUS:ACO*), using history-related knowledge and understanding in order to explain the present situation (*GC:EP*) or understanding present-day values (*MUS:ACO*). In *SoD* there is, besides, an especial ambition to encourage children to examine things, pose questions, and – enjoy learning.

2. Agency and opportunities for learning

When concerning, how meanings can be created by game narrative design, the concept of ’agency’ comes up. According to *Routledge Encyclopedia of Narrative Theory* (2005) “[c]entral to agency are the questions: what is an action (versus an *’event’, a ‘happening’ or a ‘state’) [- -]? Whose action is it (including who can be held responsible for it)? Is it meaningful and morally ‘good’ or ‘bad’?” (9). In the context of digital software design agency is closely linked to user’s goals and plans, which are the resources for her actions. Wardrip-Fruin (2009) describes agency exemplifying it by SimCity as: “a process designed to transition players, through experimentation and feedback, from their initial assumptions to an understanding of its procedural city” (345).

Tanenbaum and Tanenbaum (2009) have proposed that especially when game playing and a story intersect, agency could be viewed as a commitment to meanings. By the commitment-part of their definition Tanenbaum and Tanenbaum (2009) mean player-performer’s improvisation within a game story, and as it has to take place through a system largely determined by the game designer, the commitment is further considered as a conversation between the player and the designer, conducted via game story. The meaning-part of the definition foregrounds the player’s intents, which underlies her choices. Thus, it is suggested that “game designers should strive to create game and narrative experiences in which the player can demonstrate commitment to the experience, and, crucially, where that meaningful commitment is reinforced by the game’s behavior” (Tanenbaum and Tanenbaum 2009, unnumbered).

Just like constructive learning process requires learners to actively engage in the constructing of meanings via various activities, agency in games includes the player’s goals, plans and intentions, which – using the Wardrip-Fruin’s (2009) definition – take the player through experimentation and feedback, from their initial assumptions to an understanding of the procedural subject. Furthermore, the goals, plans and intentions created in shape of the player’s story-related improvisation, which is demonstrated in terms of the system, could be considered as a certain type of commitment to meaning.

3. Narrative and game rules: The design space for instructional game narrative

With the Semiotic-Cognitive Model of Narrative narrative is seen to be constructed by the designer and the recipient through a continuous reflection between four constitutive areas (Äyrämö, *forthcoming*). The first two areas are the Story Components, which comprise the fictional reality, and a Story as a Complex System of Facts, which is considered as a structure of functions (an approach originating from Propp’s, 1928/1968, pioneering work). The rest two areas are the cognitive Response to Narrative Stimuli, which are our mental pictures created cognitively of the contents, and the Material Representation and Multimodal Discourse, which is the only material and perceptible of a narrative work.

Narrative digital games – applying various types of game rules – are especially capable to foreground the above-described narrative areas on unique ways. Generally, the processes of narrative meaning making include the recipient’s perception and inspection of the material representation and multimodal discourse. The successful perception results as mental images constructed in the recipient’s mind. This as a whole is considered to comprise the narrative signifier. The signified-part, likewise, is considered as twofold. First, there is the fictional reality created of certain minimum components (the world, the objects, the character(s), the events, the goal(s), the challenges, and the emotional reality). On the area of the Story Components the recipient keeps on eye especially the orders of *internal logic* of the story. To raise plausibility and engagement the story must, above all, be faithful to itself. Moreover, the logic on this area governs how the recipient completes the gaps of narration with her existing knowledge. Furthermore, in order to interpret narrative meanings, the recipient judges the story contents relative to their significance for the overall course of events in the story. This is when the recipient starts to construct narrative on the second semiotic level of functions, where some of the contents are more important and others are rather supplementary. Furthermore, when recognized as functional structures, the story contents can constructed by the recipient as second stage meanings or connotations, instead of mere denotations.

Ang (2006) proposes four types of game rules that frame digital game playing: the symbolic and the semantic paidea rules, and the extrinsic and the intrinsic ludus rules. Firstly, the extrinsic ludus rules explicitly form the player’s main goal in a game. The symbolic paidea rules practically dictate what the player can do and what not. Furthermore, these rules govern the relationship between physical and virtual actions. The semantic paidea rules settle how the virtual world responds to player’s actions. Finally, the intrinsic ludus rules govern how the main goal can be reached. The intrinsic ludus rules may be explicitly told, but, as often in digital games, may also be discovered by the player along the game playing.

The connections between the narrative areas and the rule types result in variation of player's speculations and meaning negotiations. If player's learning can be supported by game narrative design, then those speculations and meaning negotiations should be essential for the learning process. The DSIGN model (Table 1) sets Ang's game rule types and the areas of Semiotic-Cognitive Model of Narrative to intersect. Next, the totality of the 16 cells of the DSIGN model is specified and illustrated using samples from three learning game analyses.

Table 1 The DSIGN model. Numbers in the cells indicate the order of discussion in the next chapter

The Area of Semiotic-Cognitive Model of Narrative/ Ang's rule type	*Extrinsic Ludus Rules*	*Intrinsic Ludus Rules*	*Symbolic Paidea Rules*	*Semantic Paidea Rules*
The Story Components (signified)	1	4	2	3
Complex System of Facts (signified)	5	8	6	7
Response to Narrative Stimuli (signifier)	9	12	10	11
Material Representation and Multimodal Discourse (signifier)	13	16	14	15

4. Player's focus on the intersections

The description proceeds from a general game goal (the extrinsic ludus rules) to what the player is able to do (the symbolic paidea rules), to the system responses (the semantic paidea rules), and finally, what appears to be efficient or even the best way to achieve the game goal (intrinsic ludus rules). Next I go through all the four areas of narrative, and describe what the player's ponderings on each areas are concerning during game playing. This does not mean that all players would focus on every type of ponderings or meaning negotiations along the actual game playing and in every game – just like readers do not leave a novel with same kind of interpretations or reading experience.

The Story Components the extrinsic ludus rules (1) direct the player to note what she as a fictional character *should aim to do*. Usually the player gets the picture from the more or less extensive backstory. In *GC:EP*, the player is a journalist who arrives on a conflict area and strives to find out and understand what has happened, what are the parties' perceptions, or stories, about the bygone events and the current situation. In the end-part of the game, the journalist uses the gained knowledge in the form of arguments in a final interview, where she has to use arguments to rouse stress in the interviewee (who represents the ruling group, and has motivation to deny unpleasant facts). In *MUS:ACO*, the player follows the story events from young Cheyenne Indian boy's perspective and makes decisions related to his actions and lines of dialog. The target is to witness several events of the character's life and see, how the decisions made earlier inflect the last events of the story. In *SoD*, the player, as a Viking student, strives to become an ultimate dragon trainer in a Viking themed virtual world.

In connection to the symbolic paidea rules, in the context of the Story Components (2) the player explores the scope of action regarding her role in the story. In the case of *GC:EP*, player can choose the subject of the questions presented to the non-player-characters (NPCs), walk between interviewees, and take a taxi to the more distant locations. Besides, she can read articles from the computer in a library. Additionally, the player can study her (automatically saved) notes, background information and her assignment. In the final interview, player presents questions and is able to set arguments when NPCs heartbeat sound is heard. In *MUS:ACO* player can choose an action or dialog line from the offered alternatives, and at certain points, she can choose between several target locations on the map. In *SoD* the player can conduct tasks like fishing, growing up plants, taking care of diverse animals and doing favors for other Vikings (by, mainly, collecting objects and running from character to character), and conducting experiments in the lab of chemistry. Additionally, there are tasks related to taking care of dragons and practicing the flying (and shooting) by them. From tasks the player earns virtual currency, by which new animals, seeds, dragon eggs or customize-related stuffs can be bought. Additionally, along with her advancement, player can study science-related summaries from the Adventurer's Journal.

The player's observations regarding the Story Components governed by the semantic paidea rules (3) are about the consequences of her actions for the objects and characters of the story world, including the player character (PC). Furthermore, the consequences on narrator-PC may touch the narrative perspective and PC's motivation as well, and thereby give reasons on changes on symbolic paidea rules. In *GC:EP* talking to particular NPC may cause new questions to become available to the PC's awareness and reveal the possibility to get further information from the same or another NPC. In *MUS:ACO* the branches chosen mean that certain traits, skills or values are actualized. Besides, there are sometimes impacts to the immediate story events, or personal "micro" level of the story, while the worldwide "macro" level is fixed. Finally, during the end-part of the story, according to player's previous choices, some alternative options of actions are available for the PC, while some others are not, since the PC's previous choices of life do not support them. In *SoD* completing the favors and other tasks raises the PC's experience points and property, and brings new objects and tasks available, while also the preceding tasks are available.

On the area of the Story Components the player's ponderings governed by the intrinsic ludus rules (4) concern the mode, which should be adopted in order to successfully move on in the game while being empathized in the PC's role. For example, in *GC:EP* the player may be pondering especially what kind of topics to prioritize in the interviews, as the player does not have time to present all the questions available.

Regarding A Story as a Complex System of Facts the extrinsic ludus rules (5) are about the involvement type the player must adopt. According to Ryan (2004) the player involvement can represent internal or external types, or something between. In the case of internal involvement, the user situates herself in the fictional world, whereas in external involvement the user situates herself outside the fictional world in the god-like position. In all example games discussed in this article the internal type of involvement plays important role in the player experience, whereas new through-playings in *GC:EP* and *MUS:ACO* may move the player involvement towards more external type.

In the context of A Story as a Complex System of Facts, the symbolic paidea rules (6) are about how the player can govern the story events, whereas the semantic paidea rules (7) move the player's focus on how her choices impact on the totality of the story structure and plotting. On other words, as a co-storyliner, the player may strive to intrigue the course of action apart from the PC's objectives. For example, in new through-playings of *MUS:ACO* the player may select a novel alternative in order to achieve particular consequences, or simply out of curiosity.

The intrinsic ludus rules –related player ponderings on this context (8) concern how the player must deal with the narrative in order to successfully play the game. This is about player's game and narrative –related literacy skills, which include informed choices that effect on her media reading and narrative interpretations. The player may utilize her previous knowledge related to adventure game or role-playing-game genre conventions to construct hypotheses. Besides, the player may apply her previous knowledge of particular narrative genres, for example, in *GC:EP* relevant narrative genre could be detective stories. The recognition of relevant genres guides the player to focus on appropriate meaning negotiations on other areas of the DSIGN model.

The intersection between the Response to Narrative Stimuli and the extrinsic ludus rules (9) is about the player's mental pictures, expectations and conceptions regarding the main goal of the game. Likewise, symbolic paidea rules –related player's responses to narrative stimuli (10) are about her mental pictures, expectations and assumptions on what she is capable to do in the game story. These expectations may be based on the player's previous knowledge related to the subject matter of the game, or, they may arose from the previous experiences on narrative or game genres considered relevant by the player (see the case 8 described in the previous paragraph). Furthermore, the semantic paidea rules in this context (11) are about player's mental pictures, expectations and interpretations regarding the reactions of the virtual world.

Further, the player creates story-related mental pictures, expectations and situated plans of particular actions leading to success. This is the intersection between the Response to Narrative Stimuli and the intrinsic ludus rules (12). The design decisions can foreground particular manner of choices simply by naming the alternatives, as in *MUS:ACO* the Cheyenne values are familiarized using the badges of bravery, wisdom, and generosity to characterize particular selections of PC-actions. It is significant that the player's perceptions and expectations must at least slightly be a subject of change over narrative progression and game playing – otherwise the experience is absolutely boring.

In *SoD* the player's initial assumptions may be, for example, that there will be many scientific facts –related tests in the game. However, actual game playing creates mental pictures of flowing performing of manifold tasks, chemical experiments and taking care of multiple living things. At the same time the NPC's dialog lines confirm a positive feel of PC's skillfulness, diligence and solicitude. Especially farming and dragon training projects tied up with the passage of real time tempts the player to return the game repeatedly during long time spans. The regular returning, then, further deepens the player's commitment on the meanings of the game narrative. The larger bodies of knowledge (such as physical science, life science, earth science and especially, and scientific method) are introduced through NPC dialog lines in pursuance of player's bustling among various tasks or favors for other Vikings, and are thereby connected to hands-on situations – and to player's previous knowledge and experiences of similar real-world-situations. Finally, the game constructs an experience of enjoyable continuous learning without disturbing fears of being mistaken. As a Viking NPC called Hiccup says: "I had to adjust my theory on the fly when my testing showed it was false. But that's okay. All data we learn can help us get closer to the true answer!" Above all, the game narrative design alters the initial assumptions of tedious cramming for unpleasant tests into an atmosphere of passion for experimenting and learning new things.

On the area of Material Representation and Multimodal Discourse the player's observations regarding the extrinsic ludus rules (13) are about how the main goal is expressed in the game context. The player's considerations through the symbolic paidea rules on this context (14) concern whether an element on the representation is a savor of a chance to interact. In this connection, the designer has to decide, how the scope of actions is hinted and revealed to the player, how are various operations split on steps, and what qualities of activities are represent in the interaction design. For example, growing plants and vegetables in SoD comprises of the following steps: buying the seeds, planting the seeds, watering the seedlings, waiting given (real) time – the time is of different length with different plants – (or skipping this step with virtual currency) and, finally, harvesting in given (real) time limit, or, if missed, reviving wilted plants (with virtual currency), or collecting the plants to compost heap. Each action is fulfilled by a click – a simplified design decision, which highlights the step-structure of the procedure.

The player's approach on the area of Material Representation and Multimodal Discourse governed by the semantic paidea rules (15) is about how the narrative-related causalities of the virtual environment are expressed. As described by Wardrip-Fruin (2009) narrative-related causalities (and other intelligent impressions) created through interaction with a software may be hidden from user's eye, or, on the other hand, there may be an impression of intelligence hoaxing the player to believe on greater complexity of intelligence of the software than there actually is. What the player can speculate largely depends on how the output is represented using the vide variety of the digital multimodal means of expression. In digital games the possibilities encompass the expressional conventions of any imaginable preceding media form. The player's intrinsic ludus rule –related meaning negotiations (16) in the context of narrative representation and discourse are about if the usefulness and effectiveness of a particular action are contextual for story events, and not only for the game context. The currency and the shop in *SoD* offer here an example, which is more contextual for the story than a plain point system would be.

5. Discussion

It has been demonstrated above, how narrative and game rules can combine in various ways creating rooms for *co-storyliner's meaning negotiations* regarding narrative and game agency. The negotiations concern, especially, what can be done, who can do it, what is the meaning of that action for game playing and narrative contexts, and furthermore, how are those contextualized meanings reflecting with player's foreknowledge. In instructional game narrative design, separate cells of the DSIGN model can play different roles. Basing on the preceding section of the article, couple of regularities can be preliminarily proposed (see a summary in Table 2).

If the player aims to success and find out the intrinsic ludus rules of a game, she conducts experiments within the limits of symbolic paidea rules and reasons on the strength of the feedback gained through semantic paidea rules. Thus, the columns of symbolic and semantic paidea rules cover the creation of fortunate circumstances for learning: factual and conceptual knowledge related to the learning objective broken down and, perhaps, situated on a larger context. In narrative games the fictional world offers that context. It is created by the story components: characters, locations, and objects including the related attributes. Besides, there must be events on both physical and emotional realms. On the area of A Story as a Complex System of Facts (especially on the cell 7) the design decisions can reveal designer's more profound view on the topic. In *SoD* the player's actions result almost inevitably as PC's development, and development leads to significant diversity of the scope for action – this could be seen as an analogical view to learning – remember what Hiccup said about false theories!

The desires, goals and plans related to player agency are not necessarily the same as the main goal of the game presented in extrinsic ludus rules, but the ones formulated by the player as *a co-storyliner*. Regarding the most effective placing of learning objectives, which involve understanding and application of procedural knowledge, the row of Response to Narrative Stimuli and the column of intrinsic ludus rules seem to be the most important areas of design. Besides, the learning objectives can be situated on the story world (the cell 4), as in *GC:EP* regarding the procedure of interviewing. Besides, the designer must take into account what the game requires from its players regarding various literacy skills (the cell 8) bearing in mind also the target group's expected cultural foreknowledge and narrative competence. Furthermore, the potential-based narrative design must be created so that, when the player infers intrinsic ludus rules together with creating mental pictures of the story contents, the design decisions regarding the combination of the two (the cell 12) clarifies the key points of the procedural learning objective. The designer's concrete tools for directing and delimiting player's observation regarding intrinsic ludus rules belong on the area of Material Representation and Multimodal Discourse (the cell 16), but to use the means of multimodal discourse effectively, the intended experience (on the cell 12) have to be worked out beforehand or in tandem.

Finally, on the column of extrinsic ludus rules, narrative design is largely characterized by the designer's approach to learning (on the cell 1), which determines the foundations for the pedagogical script created through symbolic and semantic paidea rules. The player's involvement type (on the cell 5) depends, firstly, on what is the role of empathy in the designer's learning approach, and secondly, on the (designer's view of the) characteristics of learning objection. Besides, the formation of extrinsic ludus rules indicates some generalized arguments or assumptions regarding the learning object (on the cell 9). Moreover, the situation where the extrinstic ludus rules are expressed (the cell 13) is usually also the situation, where the player creates the first expectations regarding the game playing, narrative and the subject matter.

Table 2 The DSIGN model completed with the viewpoints, which guide the learning game design in each cell

The Area of Semiotic-Cognitive Model of Narrative/ Ang's rule type	*Extrinsic Ludus Rules*	*Intrinsic Ludus Rules*	*Symbolic Paidea Rules*	*Semantic Paidea Rules*
The Story Components (signified)	Approach to Learning	Learning objective as a course of action	Learning objective broken down into story components (factual and conceptual knowledge)	Attributes related to learning objective
Complex System of Facts (signified)	Involvement type: The foundations for pedagogical script	Cultural and media -related foreknowledge and skills	Fortunate circumstances for learning	Profound (meta stage) view of the nature of the subject
Response to Narrative Stimuli (signifier)	Generalized argument about the subject of learning objective	Key points of learning objective (procedural knowledge)	Learning objective as a change of player assumptions	What kind of questions the student should be asking from herself regarding the learning objectives?
Material Representation and Multimodal Discourse (signifier)	How the player is informed about the main goal? What kind of expectations are intended to rouse?	Steering the player's observation on the essentials. Introducing abstract concepts utilizing game elements.	How actions are represented (metonymical choices). Sensory-choices (media-form - related choices)	Representation of the sphere of actions (metonymical choices)

Large amount of player's speculations during game playing concern agency, and in narrative games, it is agency over elements of fictional reality of game narrative (internal involvement of the player), plotting the story (external involvement of the player), or both. Tanenbaum and Tanenbaum (2009) defined agency as commitment to meanings, were commitment meant "a conversation between the player and the designer, conducted via game story" (unnumbered) and 'meanings' pointed out to "the player's intents, which underlies her choices" (ibid). Basing on what has been specified through the DSIGN model, player's intents in narrative learning games can be further seen as learners' active engagement in constructing meanings via her dialogic activities, in accordance with the view of constructivist learning. Besides, in form of the DSIGN model, I have now proposed a guideline for instructional game narrative design, analysis and assessment.

6. Conclusions

The DSIGN model could be applicable on several purposes, including design, analysis and assessment of learning games. The model can structure hermeneutic-interpretative analysis focusing on how meanings are created through game narrative design. Besides, the proposed approach can guide learning game designers to better situate the learning objective and the principles of instructional design and educational thinking, and more generally, to more effectively utilize meaningful relationships between game rules and narrative design. Moreover, analyses applying the proposed model may also strengthen the assessment process of existing learning games. When thoroughly game analysis is conducted, it can be reviewed, if the player's meaning negotiations on various cells of the model meet the explicitly told learning objectives.

In future, still more analyses should be conducted with DSIGN model for narrative learning games to verify the regularities of instructional game narrative design.

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Word Towers: Assessing Domain Knowledge With Non-Traditional Genres

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Abstract: This paper presents the design, development and the results of a pilot study for Word Towers (WT), an educational game that combines gameplay mechanics from board-style word building and arcade style tower defense games. To our knowledge, this is the first ever attempt to merge these game genres into a functional educational game. Our efforts open the possibility for other learning games to be reworked into new genres, increasing novelty and player engagement. Expanding the range of genres also allows for learning games to reach a wider audience. The goal of the WT is to provide a natural method for measuring domain expertise and knowledge by hiding the complexity within the level progression. In the prototype developed for showcasing our design, the domain is chosen to be the English language and the entire English dictionary is available to the player. While a design goal is to have WT eventually measure several different constructs of the English language, spelling was the only construct used for this pilot study. Each level is designed to not last longer than two minutes to promote reinforcement of the learned concepts by repetitive gameplay. Methods for integrating pedagogical principals with the game mechanics of the word games and tower defense genres are discussed. Results of a study on non-native English speaking students by measuring their performance via level progression and comparing these to native English speaking students are presented. Participants in the pilot study also provide feedback on their enjoyment of the game. These responses were mostly positive and showed initial promise that learning games can be moved successfully into new genres and still result in an enjoyable playing experience. Finally we measure learning gains in WT and prove that the gains are not compromised by the shifting of genres.

Keywords: language games, tower defense, game mechanics for assessment, word games, The LM-GM model

1. Introduction

Developers of learning games have a tendency to restrict games for certain learning domains to specific game genres. Children of different ages and genders prefer different gaming genres (Sherry et al, 2013) and restricting learning domains to specific genres limits the game's potential audience. Being flexible in regards to game genre allows games for some learning domains to reach a wider audience than they normally would. There is some debate as to the wisdom of even classifying games into genres, a concept some argue is carried over from older forms of media and does not apply well to games (Apperley, 2006). Boundaries between genres often collapse under close scrutiny and this opens the ability to shift genres without damaging the core mechanics of the game. One example of a learning domain that has a genre restriction is word games. The classic word game is Scrabble, and Words with Friends is a recent example of a popular word game. Both of these games follow a very similar gameplay style. While they have both been successful commercially, those who do not enjoy this style of gameplay are left out of the experience. In an effort to break word games out of this gameplay style, we created a tower defense word game called Word Towers (WT). Players spell a word to build a tower, which then shoots at passing enemies. The longer the word is the more powerful the tower is and the farther it can shoot. Through this mechanic, players are encouraged to find and spell longer words. A player can also upgrade a tower if they can build a new word by adding some letters to the pool of letters in an existing word tower. As the player advances through levels the difficulty increases as more enemies with more health pass by. This in turn forces the player to build more towers and try to make each one as strong as possible. This made level advancement a measure of spelling skill. This project had two research questions.

- Can level progression be a successful measure of skill?
- Do players enjoy a word game in this genre?

Successfully placing the learning of a word game into a new genre would imply that a similar genre transfer of other learning games would also succeed. This paper will discuss the reasoning behind this attempt to transfer learning games. Section two discusses related work and challenges facing learning games. The third section analyzes how to design game mechanics for skill assessment. Section four discusses hybrid models of pedagogy and game mechanics, and the modifications we made to build WT. We then discuss word games and tower defense games and how their mechanics can be combined. Section 6 covers our design of level difficulty as a means of player skill assessment. We then present our methodology and results in sections seven and eight.

2. Related work

A key problem facing education today is that children are coming into schools having been enveloped by technology all their lives (Prensky, 2001). Today's incoming students are the first to have lived with the current dissemination of technology, rather than having had it introduced later in their lives. It is known that languages learned later in life are encoded in different part of the brain than those learned at a young age. This leads to what Prensky (2001) calls digital natives and digital immigrants. So far, we have been teaching digital immigrants in our schools as children coming in have not been so steeped in technology. They ended up learning technology later in life and thus learned it similarly to a second language, in that while they may be fluent in technology use, it is not native to them. This key difference changes the way in which they work with technology as well as the way that they learn from it. We have always been digital immigrants and so our schools are designed to teach in this fashion and make use of technology as digital immigrants would. Now, as digital natives enter our schools, the system is not able to work well with them (Prensky, 2001). They inherently see technology differently than previous generations. While this provides a significant barrier to educators, it also provides an opportunity for educational games. Digital natives will learn better and easier from games than digital immigrants. Developers who can tap into this difference and make games for digital natives stand to see a significant increase in learning compared to learning amongst digital immigrants.

Gose (2014) examined learning by game genre. Gose identified twelve game genres and nineteen learning concepts. He then determined which genres taught which concepts. Of interest is the real time strategy genre. WT is a tower defense game and therefore fits into the real time strategy genre. Gose determined that this genre taught seventeen out of the nineteen learning concepts. The only two it did not teach were computer programming and crafting. Out of the seventeen that it does teach there are two concepts of interest. The first is reading comprehension. Writing and reading go hand in hand and spelling is a key component of both. A person may be able to figure out a word when reading it, but not knowing how a word is spelled prevents them from writing it. While WT only works with spelling for now, it will eventually work with multiple aspects of the English language. As players encounter these new aspects, reading will become more important. The second concept that real time strategy games teach that is significant to this project is critical thinking. Formulating and deploying a strategy in real time clearly takes critical thinking skills and this was the concept that real times strategy games were rated highest on. Engaging players through critical thinking is important and can help increase learning gains.

Peterson (2013) wrote extensively on the subject of computer aided language instruction. Central to this was second language acquisition, where a person learns a second language with the help of a computer. When computers first entered the scene, behaviorist psychology led the learning field. Since behaviorism dictates that repeated drilling is the best way to reinforce learning, computers seemed a natural choice as both a teaching and a research tool. As behaviorism was phased out and new learning theories took its place, the role of the computer within learning and research changed as well. Computer aided language learning research has followed this trend and has been shaped greatly by the availability of computers and the growth of the internet. This has led to a great increase in language learning with computers research recently. However, most of these studies focus on simulation or role playing games. Positive and negative aspects were found for both of these genres. Role playing games showed that both commercial and language purpose games led to important teacher and learner interaction, but had a risk of high cognitive load which could distract from learning. Simulation games showed great vocabulary improvements, but low level learners needed a great amount of teacher assistance in order to play the game. These drawbacks show the potential benefits of a genre shift. Being able to resolve some of these issues by presenting the learning through a different genre would be a great help to those learners who are particularly bothered by them.

In order to assess a learner's knowledge level, their observable actions must be mapped to their underlying skills (Augustin et al, 2011). It is important to know not only what action they took, but why they decided to take that action. By limiting player actions to only those that explicitly help them reach their goal, or specifically hamper their ability to succeed, it becomes easier to map each action to knowledge. Keeping possible distractor actions to a minimum is another way to expedite this as well. Another method is to also keep the game itself short for repetitive gameplay, a game type known as burst games (Amresh, Clarke and Beckwith, 2014). Burst games allow a player to learn by doing while keeping the experience short so that failure does not mean hours of lost work. Amresh, Clarke and Beckwith (2014) used this technique to teach science concepts with their GameScape project. WT was also designed to follow this burst gameplay style. Players were expected to spend only two to three minutes on any one individual level. This reinforces learning concepts through repetition and gives the player a chance to see their repeated mistakes.

3. Designing game mechanics for assessment

A challenge facing developers of learning games is accurate assessment of student knowledge without breaking the flow of the game (Shute and Ventura, 2013). This "stealth" style of assessment works (Shute, 2011) best when incorporated directly into the core game mechanics. One conceptual framework that can help guide design of these mechanics is evidence-based design (EBD) (Mislevy and Riconscente, 2006). Using the EBD framework provides a method of designing assessment models which helps ensure assessments are valid and accurate. EBD is based on three underlying models the first of which is the competency model, which represents the students' knowledge. The second is the task model which describes scenarios in which a student can demonstrate their knowledge of a topic. The final model is the evidence model, which looks at the results from the student performing a task and evaluates their knowledge and passes it to the competency model. This interaction flow fits well into a gaming environment. Players usually receive some form of feedback about their performance as their health goes down or their wealth goes up in the game. Following this model, we build WT to incorporate this feedback into the difficulty. Players who are good at spotting words to spell will be able to build more, stronger towers to defend their city from the invading pirates. These players will have gold left over at the end of the level and will be able to advance, where more ships will attack and further challenge their spelling skills. Players who are not as good at identifying words to spell will lose all their gold and be prevented from advancing. This system provides the overarching feedback system which provides players a definite moment of assessment at the end of a level. Immediate feedback comes during the level as a successful player watches the enemy ships sink, while a struggling player can see the enemy ships sail into his or her town unhindered.

4. Hybrid models

Arnab et al (2015) created the LM-GM (Learning Mechanics – Game Mechanics) model for integrating learning into serious games and assessing the relationship between their game mechanics and pedagogy.

Figure 1 shows the model which has on each row pedagogical principals and then the most closely related game mechanics. The two central columns each hold the core mechanics with the leaf nodes holding supporting concepts or mechanics. The first row of note is the assessment row, which is identical on both sides of the model. Our project WT was designed as a spelling assessment game. The second row of note is the repetition row from the learning mechanics side. The matching game mechanic contains levels. WT was designed to use short levels for repetitive burst gameplay. A player who repeats a level multiple times will eventually gain enough skill to overcome that level and advance. This makes level progression both a means of teaching and a method of skill assessment.

WT uses this model as a base and provides a modification of this model. The main goal of WT is skill assessment, rather than learning. To do this, we modified the LM-GM model to be an AM-GM (Assessment Mechanics - Game Mechanics) model. Our modified design uses only those elements from Figure 1 that have a bold border.

Our version of the model focuses more on assessment, and removed several elements that were not relevant to our goals with WT. The repetition and assessment rows were kept from the original. There are also several rows that still play an important role in WT, such as observation and participation.

5. Word games and tower defense

Word games such as Scrabble often pit two players against each other. The goal is to spell out words from a random set of letters. Harder to use letters are worth more points and spaces on the board can also be worth additional points. Players take turns trying to build a word with their letters in combination with the words already on the board. This requires players to employ both spelling knowledge and strategy as they build valuable words and try to not leave many options for their opponent. The game usually ends when all of the letters have been used up and the player with more points is the winner. Tower defense games have set areas on the map which are called lanes. Enemies move through these lanes towards the goals on the other end. The player must build towers alongside these lanes, which then fire upon the nearby enemies. Players build these towers by spending resources. The goal of the game is to defeat the enemies before they reach the end of their lane. The game is over if too many enemies make it to the end. Tower placement and resource management are key parts of the strategy in tower defense games and placing the correct towers in key locations can make the difference between a win and a loss, particularly on higher difficulties.

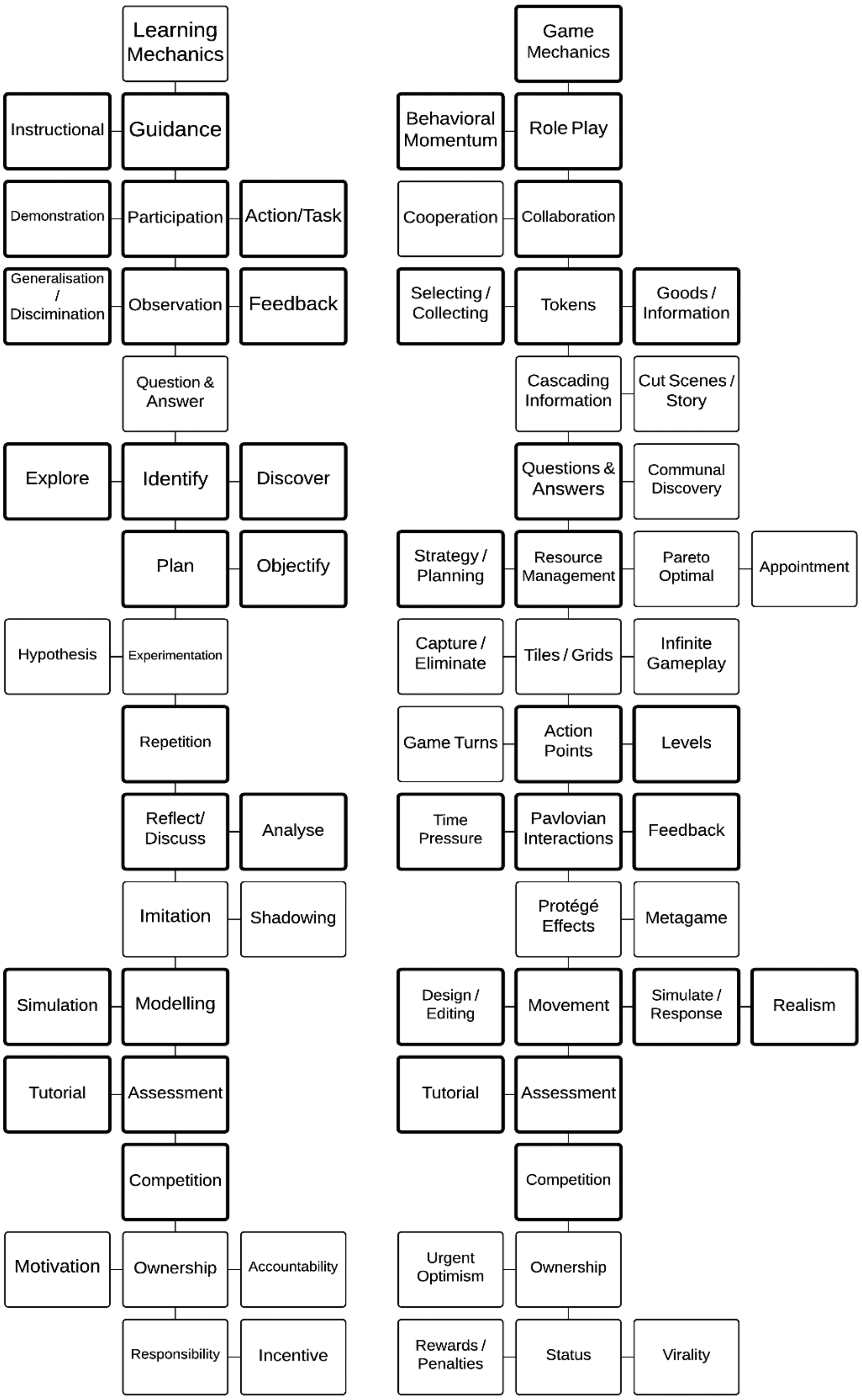

Figure 1: The LM-GM model recreated from (Arnab et al, 2015).

With WT, we wanted to combine the elements from the two game genres into an appealing game with a target audience of middle school aged children. Players were given a set of random letters to spell a word from. At the beginning of a level there were only five letters to choose from, but this number would increase during the level. The chance of drawing each letter was based on the letter frequencies from Scrabble. The player could also pass on a given set of letters that they did not like. Players would choose where to build a tower and then select the letters to build their word. The longer the word was that they spelled, the more powerful the tower was and the longer the range it could shoot enemies at. The goal of this design was to reward players that were able to build longer words and encourage players to try and build longer words. There was also an upgrade function players could use. Using this, players could add new letters to towers they had already built making those towers stronger. All the letters from the previous word had to be used, but not in the same order. For example, the word sand could become Sunday by adding the letters u and y. This mechanic was designed to follow on to Scrabble's core mechanic of building new words using letters from words already on the board. It also encourages players to find other new combinations rather than just those from their current letter pool. This allows for greater learning and refinement than would be possible with just straight word building.

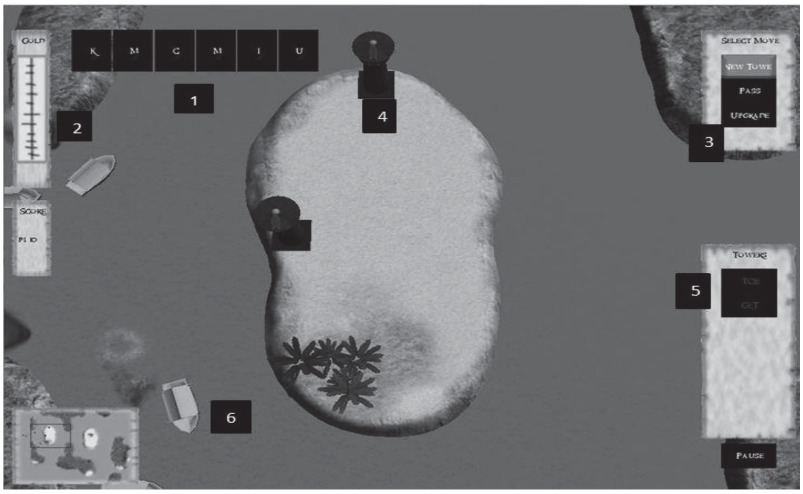

Figure 2: A screenshot of Word Towers

Figure 2 shows the main game screen of WT. Players start at a main menu which leads them into the first level. The player can scroll around the level to place towers on different areas of the game map. There are six key elements to the interface, which are explained below in Table 1.

Table 1: An explanation of key elements from the main game screen of Word Towers.

Screen Element	Description
Player Letter Pool	These are the letters the player currently has to choose from to build a new word.
Player Gold	Gold represents the player's life total. Losing all of it means that they lose the level. Some Gold is lost for every enemy that makes it through the level alive.
Move Selection Area	From here the player can select if they want to build a new tower, which they will then place on the ground and choose their word. They can also pass on their current letters and upgrade an existing tower from this area.
Player Towers	This is an example of a weaker tower that a player can build. This tower will shoot at enemies that sail nearby.
Tower List	This is a list of all towers that a player has currently built in the level. This provides a quick reference for the player so they can spot upgrade opportunities more easily.
Enemy Ships	This is an example of an enemy ship sailing on the water. This particular enemy is the weakest variety.

6. Level progression as skill assessment

WT was designed to assess knowledge through level progression. Difficulty followed a saw tooth pattern along three stages of difficulty. The difficulty would increase each level until the four where the pattern would start over at the base difficulty. This was done to give players a break and prevent either frustration or cognitive fatigue from setting in on the player. Throughout the level, the player received immediate feedback on their performance by the progress of the enemies and how much gold they had left. Delayed feedback was given at the end of the level when the player was either able to continue or had to replay the level. In language learning, immediate feedback is important (Charles, 2005). Placement or proficiency tests can take a long time to return results and also do not usually offer analysis of where or how a student can improve their skills. A goal of WT is to eventually have it measure player skill with a different mechanic of language on each level. Failing a particular level would imply that the English mechanic from that level is an area that the student needs to improve in.

Implementing this was not possible in the timeframe set for the showcase prototype. For the prototype that showcased the design, difficulty was only determined by the number and the strength of the enemy ships.

7. Methodology

We performed an exploratory study with two goals in mind. The first was if level progression could be a successful measure of a player's spelling skill. The second was to assess how enjoyable WT was for players and if the deployment of language learning in a tower defense game was engaging. Players were given a sheet of instructions on how to play the game. The player would then play WT until they failed a level and then would return and fill out the form. Players filled out demographic information about themselves and their English background and rated their own skill as well as WT on a number of rating scales. All of these scales used one as the lowest, least desirable, value and 5 as the highest, most desirable, value. The game itself also printed out a text file which recorded several pieces of data. This file contained how long a player took to build each tower since the previous tower or the beginning of the level if no towers were built yet. The times for the first tower of each level were excluded from these results due to a programming error that caused extraordinarily large times to be reported. At the end of a level the file also printed out how many times a player passed on their selection of letters and how many times they upgraded a tower. Participants were students from Arizona State University Polytechnic campus. In total twenty five responses were recorded. Six of these responses came from non-native English speakers. One of these was a Graduate student but all other participants were undergraduate students. Two of the eight females who responded were non-native English speakers. Most respondents, seventy two percent belonged to Software Engineering majors. The number of years that respondents had been in college was fairly well distributed with three to four years being the highest portion at thirty six percent. One of the non-native speaker responses was an exact duplicate response. Both copies also had a compliance issue that caused their data to be indistinguishable from a native speaker's response. Finally, one native speaker participant's data file was not properly transferred. All four of those responses were excluded from these results.

8. Results

Self-spelling rating was 3.88 on average for native English speakers. For non-native speakers it was down to 2.75. Spelling game use was low in both groups, but was higher among native speakers than non-native speakers with averages of 2.18 and 1.5 respectively. Self-reported skill with word games was also below average for both groups, but the two groups were closer to each other on average with 2.94 for native speakers and 2.75 as the average for non-native speakers. Native speakers averaged 2.76 on confidence in their abilities at WT while non-native speakers averaged 2. Participants were asked to rate if they felt that playing WT repeatedly would help improve their ability to spell. Non-native speakers averaged a rating of 4.25 while native speakers averaged 3.29. None of these results are particularly surprising. It is to be expected that non-native speakers will have less confidence in their English abilities and be less confident at word games in English. Likewise, it also follows from that result that native speakers would rate themselves higher in their performance at WT.

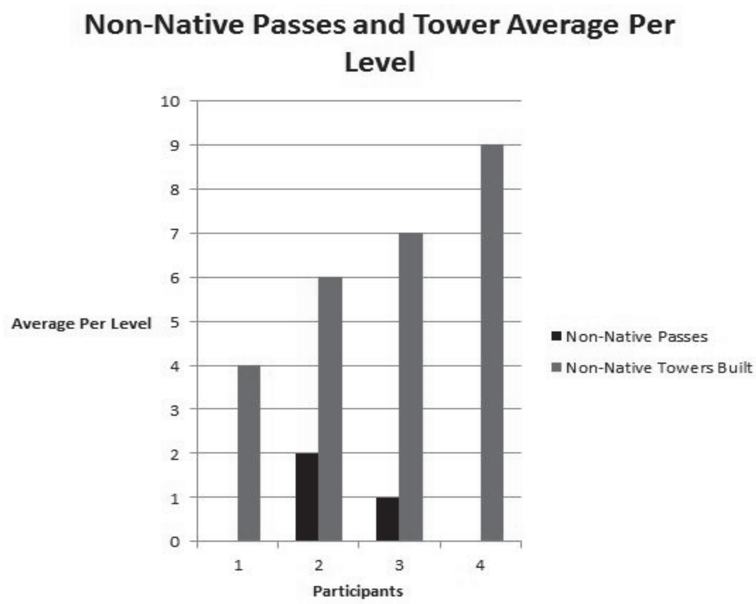

Figure 3: A chart of the results of total towers per level, passes per level for Non-Native speakers

Most participants did not advance beyond the first level. It was not immediately clear if this was due to player skill, difficulty, limited instructions or if participants just stopped of their own accord. This made it impossible for us to draw conclusions about level progression as a measure of skill. Three native speakers advanced to the second level and stopped there. Three other native speakers all made it to level five before stopping. Non-native speakers all stopped at the first level. Non-native speakers built 9.5 towers total on average, and they averaged 6.5 towers per level attempt. Native speakers averaged 16 towers total and 7.86 towers per level attempt. This average number of towers does not include one of the participants who advanced to level five as they built 105 towers, which was more than three times the next closest participant. No other participants were excluded from those averages. Total number of passes on a letter set was low overall for non-native speakers. Two did not pass at all, a third passed once and the final passed six times. Native speakers averaged 3.06 passes total and 1.52 passes per level attempt. These averages again exclude the same participant as the previous data, as they passed 28 times total which was again significantly higher than other native speaker passing totals. Only one participant took advantage of the upgrade feature, and even then they only upgraded a single tower. This participant was a non-native speaker. This is unexpected for a non-native speaker, but this participant rated themselves highly on spelling skill and confidence with WT.

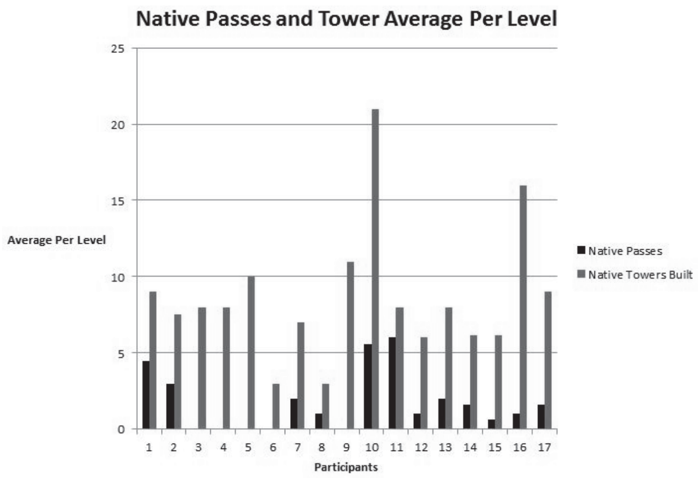

Figure 4: A chart of passes and towers per level for Native speakers

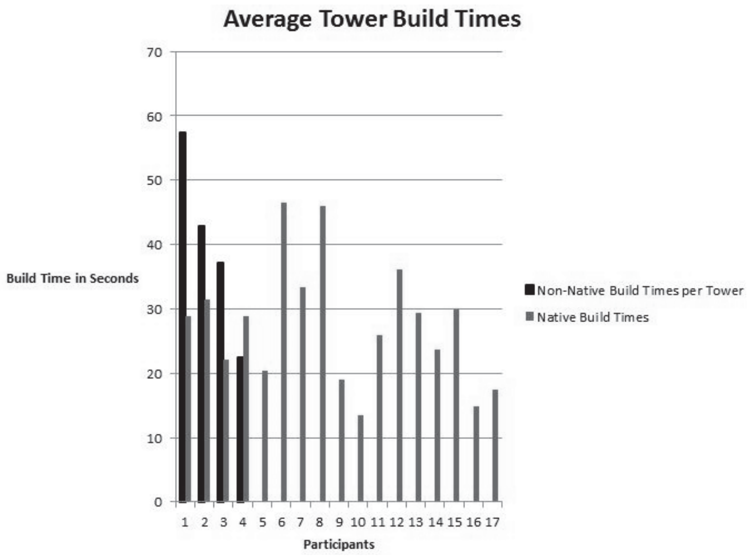

Figure 5: The average time in seconds to build a new tower for both groups.

Participants were also asked to rate their enjoyment of the game on another scale of one to five. Enjoyment was above average for both groups. Native speakers averaged 3.29 while non-native speakers actually rated the game higher with a 4.5 average. This enjoyment rating is encouraging for the second research question of this project. Moving a word game into a different genre was desirable to expand potential audiences but if the results were not enjoyable then moving learning games into new genres might not be a worthy endeavor. However, participants generally reacted well to the game and wrote favorable comments in an area in the form for additional comments. One native speaker who rated enjoyment as a four and reached level five commented:

> *"I definitely like this style of game. The tower defense gamification did not seem forced and the idea that harder words make the towers stronger was well done. I did not use the upgrade tower functionality because it seemed that building a new one was more efficient."*

There were also many comments about how the game could be improved, but most of these focused on graphical enhancements and better instructions being in the game itself. One participant commented:

> *"This game needs to have an in game wizard showing how to play, the instructions don't clearly communicate the instructions in a way that a person can pick up the game for the first time and know what is going on."*

This was to be expected as WT was in a pre-alpha state for this study.

9. Conclusion

WT is a tower defense game built to assess and improve player spelling skill. Only a small portion of the participants made it past the first level in the game. This made it difficult to make generalizations about measuring player skill via level progression from our results. Our other concern was to successfully bring a learning game to a non-obvious game genre and our results show initial promise in this area. Being able to make learning games in different genres would increase player interest and allow learning games of a given domain to reach a wider audience. Further work is needed to determine if learning gains are consistent across both genres. The ability of WT to accurately determine player skill needs to be reevaluated as well. A final area that needs to be further studied is a pretest and posttest evaluation of whether or not participants agree that playing WT repeatedly would increase their skill. However, initial promise has been shown that typical genre barriers can be broken and still provide entertaining games for players to learn from.

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Designing a Serious Game to Enhance Orthographic Projection Learning in Higher Education

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Abstract: Nowadays, most university or college students are Digital Natives (Prensky, 2001). Their learning style and learning culture is quite different from their parents and teachers, who are Digital Immigrants (Prensky, 2001). Many previous research studies have shown that games are a powerful and effective tool (Michael & Chen, 2006) in many educational domains, such as military training (Lim & Jung, 2013; Yildirim, 2010), marketing (Devitt et al., 2015), management (Mayer 2006), health-care (Ribaupierre et al., 2014; Lynch-Sauer et al., 2011), foreign language learning (Johnson, 2010; Ludwig et al., 2009), computer programming (Xu, 2009), computer graphics (Mustaro, 2009), job-specific skills, politics (Bogost, 2010), etc. However, there is no specific research discussing how to use serious games to improve orthographic projection learning in a higher education setting. Technical graphics are an essential and fundamental basis of a technologist or designer education. The core of technical graphics is orthographic projection. Technical graphics communication skill is a critical and significant asset for students majoring in engineering, production design, industrial design, interior design, architecture, etc. Therefore, the main objective of this research is to develop a serious game, called ITouYing, for helping university students from the Net generation (Tapscott, 1998) or the Games generation (Prensky, 2003) to master orthographic projection in novel fashion. The ITouYing game is composed of nine sub-units, including 1) Orthographic projection concept, 2) Orthographic projection knowledge quiz, 3) Plane type judge, 4) Stain in plane, 5) Front view selection, 6) Top view selection, 7) Right side view selection, 8) Three view match, and 9) Proper 3-D model selection. The effectiveness of the ITouYing game towards learning was examined by surveys in the department of mechanical engineering, aeronautics and astronautics at the National Cheng Kung University and the department of industrial education at National Changhua University of Education. The evaluation results indicated that most of the university students(54%) favor using the ITouYing game, because it can enhance orthographic projection learning effectiveness interactively (84.9%) and also promote visualization skill between a 3-D model and it's multi-views (79.9%). Moreover, the participants perceive the stain in plane unit (unit 4) is the most satisfying unit (24.5%), and the proper 3-D model selection unit (unit 9) is the most helpful unit (22.3%) for learning orthographic projection. Furthermore, for more completeness, the IToYing game should broaden the scope of the survey by including participants from more different departments, and from more different universities. The valuable feedback collected from participants will be useful to refine the ITouYing game.

Keywords: serious game, higher education, orthographic projection, ITouYing, multi-view, 3-D model

1. Introduction

Nowadays, most of students in college and university are considered Digital Natives (Prensky, 2001), their learning style or learning culture is quite different from their parents and teachers, who are Digital Immigrants (Prensky, 2001). Orthographic projection is a core element of technical/engineering graphics, but there are no obvious techniques in learning orthographic projection in higher education settings. Many previous studies have shown that serious game is a powerful and effective tool in many educational settings, but there is no specific research discussing how to use serious games to strengthen orthographic projection learning. This research investigates what makes orthographic projection learning difficult in higher education settings, and then designs a serious game, called ITouYing to help students master orthographic projection learning. The systematic five-step ADDIE model (Gagne et al., 2005) is applied to design the ITouYing game. The steps of analysis, design, development, implementation, and evaluation (illustrated in Figure 1) provide a theoretical framework to discuss solid instructional design techniques for serious game design. In the first step, a survey for determining engineering graphics learning status and user requirements is conducted to investigate the user requirements, needs, and the attitude towards adopting a serious game for learning orthographic projection. The survey results were helpful for the ITouYing game concept design. For step 2, there are nine units developed for this serious game. In the step 3, a game concept usability survey was conducted. The survey results were used to modify and refine the ITouYing game in order to enhance functionality and aesthetics toward the digital native student learning preferences. Steps 4 and 5 are not covered in this work.

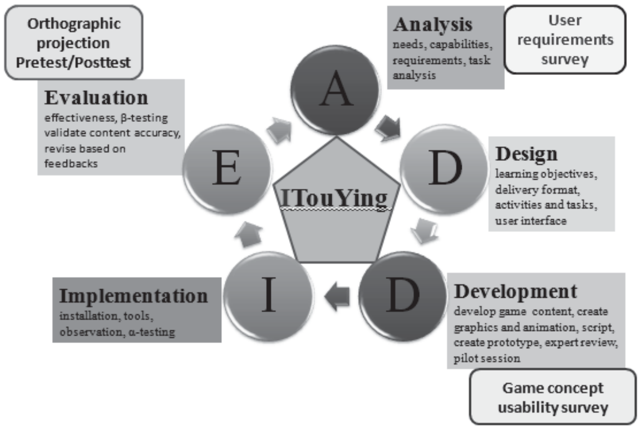


Figure 1: Systematic five-step ADDIE model

2. Learning style differences between digital native and digital immigrant

Most current students in university are Digital Natives (DN) (Prensky, 2001), and part of the games generation (Prensky, 2003), net generation (Tapscott, 1998) and iGeneration (Australian Bureau of Statistics, 2009; Rosen, 2010). Most of them carry smart phones and use them for internet access. They perform many activities using a smart phone, such as, chat with friends and classmates on Facebook, watch videos on YouTube, play games with friends, share photos with friends in Facebook, Google +, or Flick, and communicate with friends using instant messaging, and so on. The digital native learning style is quite different from the digital immigrant style of their parents and teachers. There are ten main cognitive style associated with the Games Generation as observed by Prensky (2007): 1. Twitch speed vs. conventional speed, 2. Parallel processing vs. linear processing, 3. Graphics first vs. text first, 4. Random access vs. step-by-step, 5. Connected vs. standalone, 6. Active vs. passive, 7. Play vs. work, 8. Payoff vs. patience, 9. Fantasy vs. reality, and 10. Technology-as-friend vs. technology-as-foe. Following the cognitive style changes in the digital native student, the education environment, the learning material delivery channel, and the teaching method should change to accommodate the digital native learning style and preferences.

3. Orthographic projection

Engineering graphics or Technical graphics are a fundamental and significant course in many engineering and design related departments at university, such as mechanical engineering, architecture, civil engineering, civil and construction engineering, systems and naval mechatronic engineering, aeronautics and astronautics, biomedical engineering, mold and die engineering, industrial design, interior design, product design and so on. Technical/Engineering Graphics is a universal language and a graphical communication skill used in engineering design, industrial design, interior design, medical equipment design, and patents (Bertoline 1995; Giesecke 1985; Wallach 1981; Lin 2004; Wu 2005). Engineers and designers use technical/engineering graphics to communicate their design ideas to each other and deliver their design to others. A manufacturing engineer refers to the technical graphics in order to fabricate machine elements and the assembly engineer assembles them into a machine or device. It is critical for student to master technical/engineering graphics which will benefit their studies and ensure their job success in the future. Orthographic projection is the core element in technical/engineering graphics. Other subjects are based on orthographic projection, such as isometric view, multi views, section view, oblique drawing, auxiliary views, intersection & developments, dimension & tolerance, working drawing, pipe drawing, etc. Therefore, if a student wants to master the technical/engineering graphics course, they must master orthographic projection.

4. Computer-assisted instruction in engineering graphics

As the computer has become the main assistive learning tool in and out of the classroom, there are many researchers developing Computer-Assisted Instruction (CAI) systems for teaching descriptive geometry and engineering graphics. Sueoka et al. (2001) used VRML and JAVA3D to create instructional materials (illustrated in Figure 2) for training student spatial skills. Their virtual, interactive, dynamic 3-D computer-assisted instruction (CAI) platform enhances the student's visualization skills in descriptive geometry and graphic science education. Hsu (2006) also developed a computer-assisted instruction system (illustrated in Figure 3) as supporting material for his course in “Engineering Graphics” in the Mechanical Department of the Northern Taiwan Institute of Science and Technology and Computers.

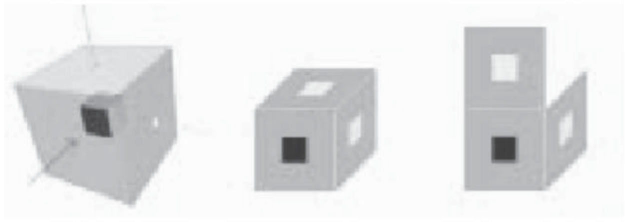


Figure 2: CAI for understanding orthogonal projection

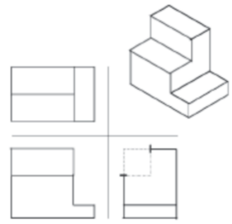


Figure 3: CAI for engineering graphics

Rafi et al. (2006) designed an interactive engineering drawing trainer (EDwgT, illustrated in Figure 4) to investigate the effectiveness of computer-mediated engineering drawing instruction for improving spatial visualization and mental rotation. Their research results indicated that factors such as spatial experience, gender, learning styles and appropriate utilization of instructional methods for a particular group can maximize their training efficacy. Their EDwgT trainer system improved student spatial visualization. Cohen & Hegarty (2008) at the University of California, Santa Barbara, used interactive animation and virtual geometric solids (illustrated in Figure 5) for spatial visualization training. Their research results point out spatial visualization skills can be improved through training and provide evidence for the usefulness of interactive computer visualizations in their training. Their participants were able to infer the shapes of untrained figures by noting similarities among the spatial features of criterion figures and remembering the shapes of their cross sections. Lin (2004) also designed a descriptive geometry teaching CAI system to assist in teaching. His research indicated that a CAI system can improve student learning effectiveness.

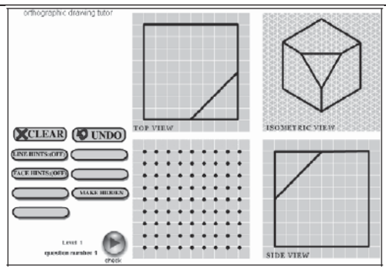


Figure 4: Interactive engineering drawing trainer

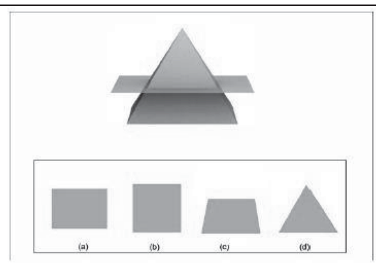


Figure 5: Animation and virtual geometric solids

5. Serious game for learning engineering graphics

Computer games form a part of children's culture (Fromme, 2003), and gaming is relative to their living and learning. According to Zyda (2005), a serious game is defined as ”a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives.” Kinzie & Joseph's (2008) research show that children love to play games and are highly motivated to engage them. Crown (1999, 2001) had developed a number of web-based games using simple JavaScript code to teach visualization skills needed for a course in engineering graphics. His research findings show that the web-based games significantly reinforce course topics, and student learning outcomes and attitudes about the course improved. Figure 6 is a screenshot of his game-like test.

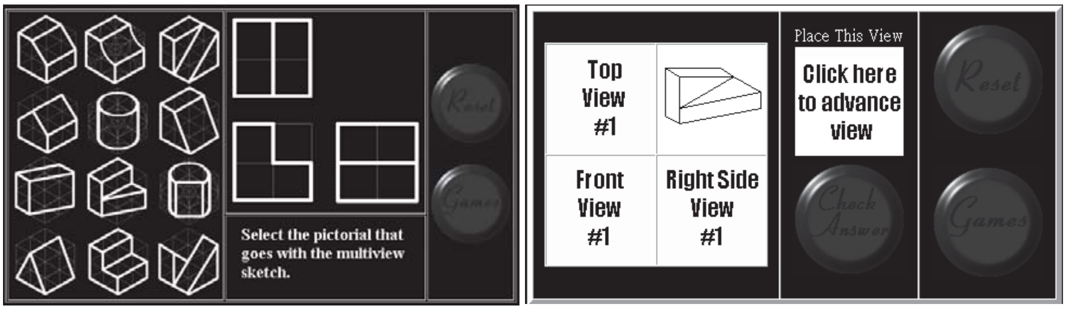


Figure 6: Screenshot of Crown's game-like test

6. Engineering/orthographic projection learning status and user requirement survey

According to Maxl & Tarkus (2009), gathering user requirements from the target group is a crucial part of the game development process. This study conducts a user requirements survey for students in the department of industrial education at National Changhua University of Education (NCUE) and the department of mechanical engineering, aeronautics and astronautics at National Cheng Kung University (NCKU). Table 1 shows the questionnaire concerning learning engineering/orthographic projection and user requirements. There were a total of 139 participants who finished the survey. Male participants numbered 115 (82.7%) and 24 (17.3%) participants were female students. The detailed participant demographic information is listed in Table 2. The detailed survey results are shown in Figure 7.

Table 1: Orthographic projection learning status and user requirement survey questionnaire

Item	Question	Abbreviation
1	Learning orthographic projection is fun.	LOPIF
2	I have mastered the knowledge of orthographic projection.	MKOOP
3	I keep up with the teacher's progress.	KUWTP
4	I draw multi-views on time.	DMOT
5	I need help for drawing multi views.	NHFDM
6	I have missing lines when drawing multi views.	MLIDM
7	Drawing multi-views easier.	DME
8	After I finish multi-views, I can't comprehend the real shape.	AFMBCCRS
9	I comprehend the real shape more by drawing isometric view.	MCRSBDIV
10	Drawing isometric view is easier.	DIVME
11	I have mastered multi-views and isometric view.	MMAIV
12	I have mastered multi-views but can't master isometric view.	MMBCMIV
13	I have mastered isometric view but can't master multi-views.	MIVBCMM
14	I often teach other student how to draw multi-views and isometric view.	OTOSDMI
15	I perceive accomplishment while finish learning multi-views and isometric view.	PAWFLMIV
16	I prefer serious game for learning orthographic projection.	PSGFLOP

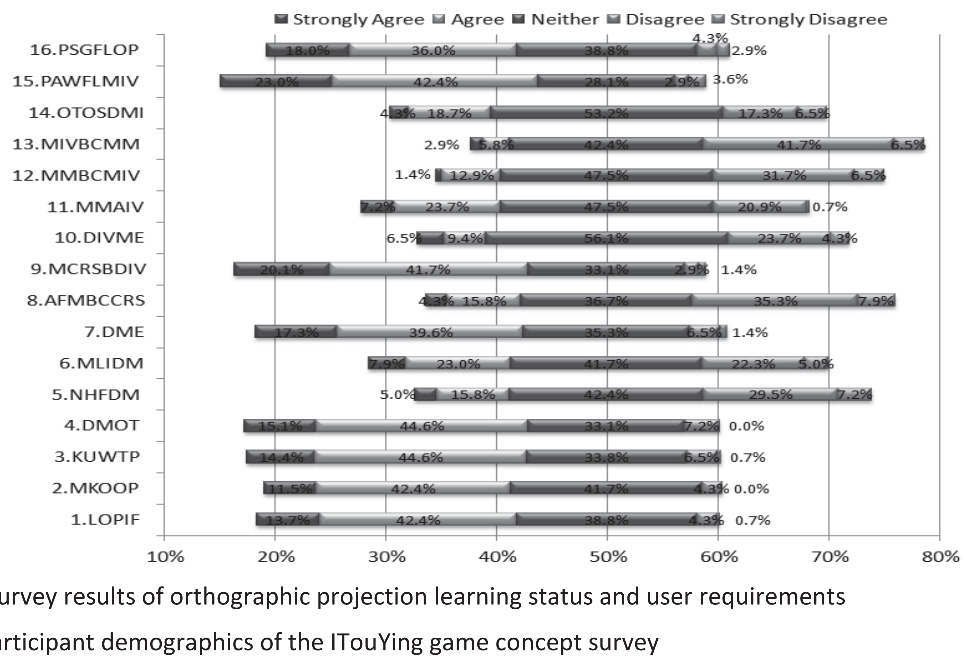


Figure 7: Survey results of orthographic projection learning status and user requirements

Table 2: Participant demographics of the ITouYing game concept survey

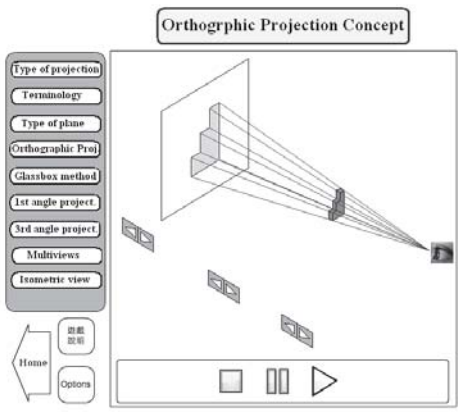
School	Department	Grade	Age	Male	Female	Total
NCUE	Industrial education (IE)	Freshman	19-29	8	7	15
NCKU	Mechanical engineering (ME1)	Freshman	15-29	34	9	43
NCKU	Mechanical engineering (ME2)	Freshman	15-29	52	3	55
NCKU	Aeronautics & Astronautics (A&A)	Freshman	15-22	21	5	26
Total				115	24	139

NCUE: National Changhua University of Education; NCKU: National Cheng Kung University

The results show about 30.9% (7.2% strongly agree and 23.7% agree) of the participants believe they can master both the isometric view and multi views simultaneously, and about 21.6% (0.7% strongly disagree and 20.9% disagree) of the participants report they can't. The survey concludes that knowledge and skill of engineering/orthographic projection of some student is under developed. About 54% (18% strongly agree and 36% agree) of the participants report they prefer to using serious game for learning orthographic projection and about 7.2% (2.9% strongly disagree and 4.3% disagree) of the participants do not like using serious game for learning orthographic projection. This shows there is high potential to design an innovative serious game for helping students to learn orthographic projection.

7. Designing the ITouYing game for learning orthographic projection

Based on the literature review and the user requirement survey results, the author designed the ITouYing game for learning orthographic projection. There are nine subunits, including 1) Orthographic projection concept, 2) Orthographic projection knowledge quiz, 3) Plane type judge, 4) Stain in plane, 5) Frontal view selection, 6) Right side view selection, 7) Top view selection, 8) Three view match, and 9) Proper 3-D model selection. Unit 1 is **the orthographic projection concept learning game.** It uses animation and video clips to introduce the basic concepts of orthographic projection. They cover the six main issues, including 1) Type of plane, 2) Type of projection, 3) Orthographic projection, 4) First angle projection, 5) Third angle projection and 6) Multi-views and isometric view. Figure 8 illustrates the user interface for the orthographic projection concept unit.



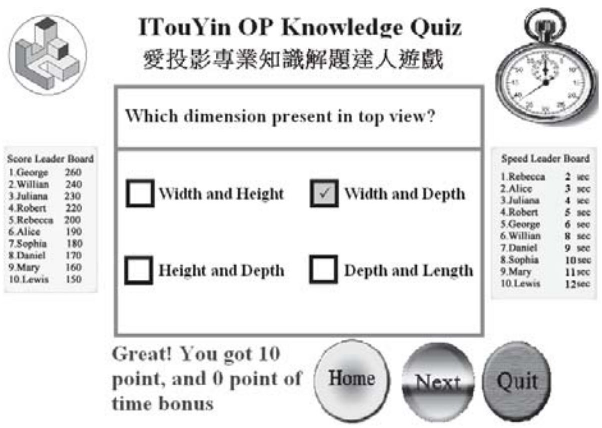
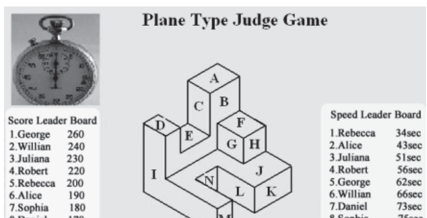


Figure 8: User interface in unit 1 game

Figure 9: User interface in unit 2 game

Unit 2 is **the orthographic projection knowledge quiz game** with time bonus. It is an in-game assessment unit to assess whether the participant has mastered the basic orthographic projection knowledge. If the participant correctly answers the question under the time limit, the participant will gain additional time bonus points. The quiz game unit also provides a score leader board and speed leader board. This game function can motivate students with a competitive learning environment. Figure 9 illustrates the user interface of the orthographic projection knowledge quiz game. Unit 3 is the **plane type judge game.** This sub-game gives an isometric view with each visible plane marked with a different symbol. The participant should press the correct button for each plane column in the answering area. The user interface of plane type judge game is shown in Figure 10.



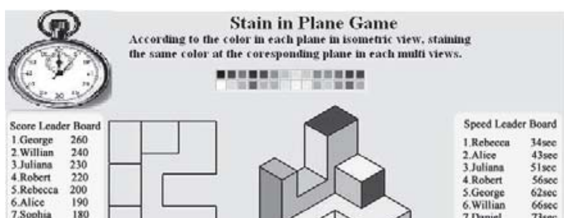


Figure 10: User interface of unit 3 game

Figure 11: User interface of unit 3 game

Unit 4 is the **Stain in Plane game.** This sub-game gives an isometric view with each visible plane marked with a different color. The participant should stain the same color at each corresponding plane in the multi-views. The user interface of plane type judge game is shown in Figure 11. Units 5, 6, and 7, are **proper view selection games**, where the participant should select a correct view from the six candidate views according to the assigned projection direction about a given isometric view. This subunit game examines whether the participant has acquired visualization skills to transform an isometric view (or 3-D model) into a multi view. The user interface of units 5, 6, and 7 are shown in Figures 12, 13, and 14, respectively.

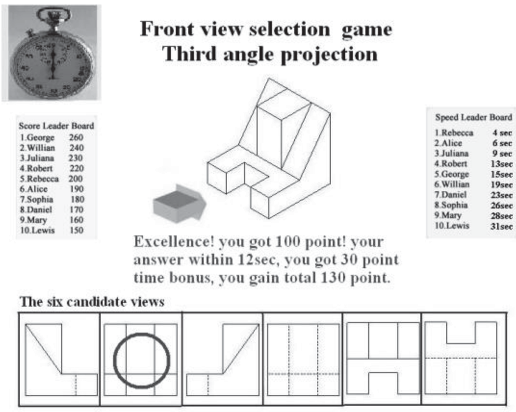


Figure 12: User interface of Unit 5 game

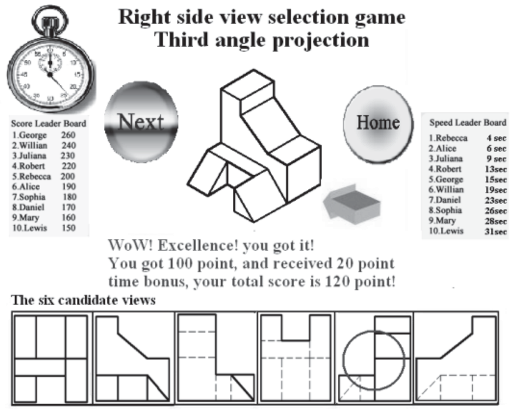
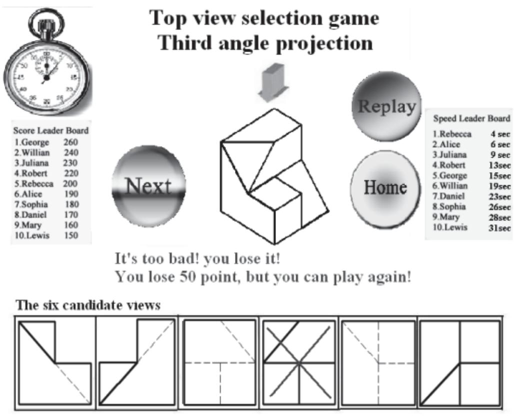


Figure 12: User interface of Unit 5 game **Figure 13:** User interface of Unit 6 game

Unit 8 of the ITouYing game is the **three view match game**. This unit gives an isometric view. According to the projection, the participant must chose the correct view (front view, top view, right side view) according to the given information and drop it into the corresponding position. The user interface of the three view match game is shown in Figure 15.



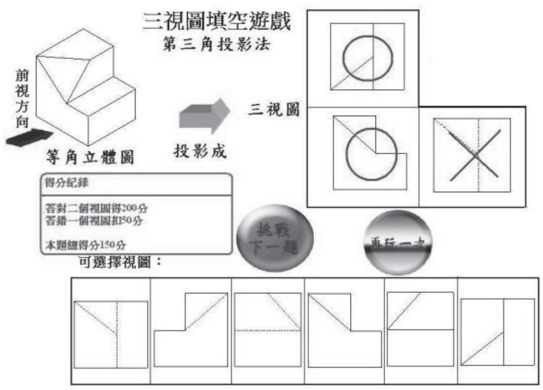
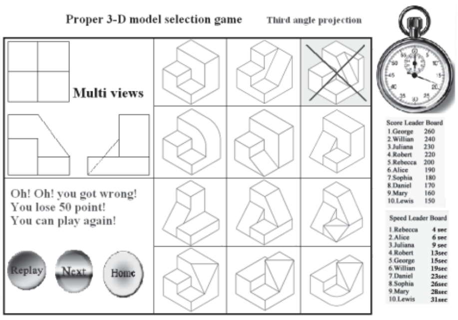


Figure 14: User interface of unit 7 game **Figure 15:** User interface of unit 8 game

The last unit of the ITouYing game is the **proper 3-D model selection game**. This subunit game provides multi-views, and the participant should select the corresponding correct 3-D model (or isometric view) from the 3-D model inventory according to the given multi-views. The user interface for the proper 3-D model selection game is shown in Figure 16.



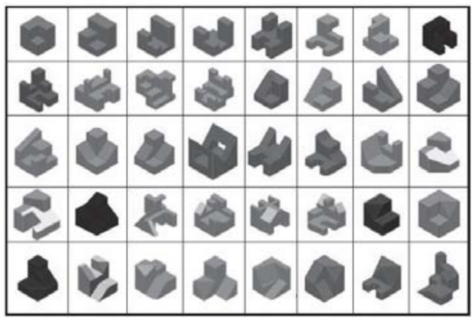


Figure 16: User interface of unit 8 game **Figure 17:** 3-D model samples in the game inventory

There are about two hundred 3-D models in the ITouYing game inventory. Figure 17 lists a sample of the 3-D models in the game inventory. Each 3-D model in the model inventory is randomly assigned to each unit for different difficulties according to the complexity of face number and face type combination.

8. Method

8.1 Participant demographic information

After the nine subunits of the ITouYing game concept was designed, the ITouYing game concept survey is conducted. This survey collected participant data from two universities in Taiwan. The participants were freshman students who majored in mechanical engineering, industrial education and aeronautics and astronautics departments. The detailed participant demographic information is listed in Table 2.

8.2 Questionnaire in ITouYing game concept survey

For the ITouYing game concept survey, there were 13 questions used to investigate the usability and user interface of the ITouYing game concept. These included whether the ITouYing game motivated participants to learn orthographic projection, enhance learning effectiveness, promote visualization skill, ease of use, challenge to play, design aesthetics, smoothly usage, fascinating play, creative design, reasonable rules, high achievements, effort to master, and whether they would recommend it to a friend. The questions and abbreviations are listed in Table 3.

Table 3: The ITouYing game concept survey questionnaire and its abbreviations

Item	Question	Abbreviation
1	1. The ITouYing game motivated me to learn orthographic projection.	1. MTL
2	2. The ITouYing game enhances the learning effectiveness of orthographic projection.	2. ELE
3	3. The ITouYing game promotes the visualization skill between 3-D model and multi views.	3. PVK
4	4. The ITouYing serious game is easy to use.	4. ETS
5	5. Playing ITouYing is challenging.	5. PIC
6	6. The ITouYing design is aesthetically pleasing.	6. IIB
7	7. The use of ITouYing is smooth.	7. UIS
8	8. Playing ITouYing is fascinating.	8. PIF
9	9. The design of ITouYing is creative.	9. DIC
10	10. The rules of ITouYing are reasonable.	10. RIR
11	11. Playing ITouYing feels like achievement.	11. PIHA
12	12. I make great effort to master ITouYing.	12. MGFMI
13	13. I am glad to introduce ITouYing to my friends and classmates.	13. GIIFC

9. Data collection and analysis

In order to collect participant opinions and attitudes about the ITouYing game concept, the 5 point Likert scale is adopted in the close-end survey questionnaire. There are 4 open-ended questions administrated to the participants to collect their opinion about the advantages and disadvantages of the ITouYing game concept, and the most satisfied unit and the most helpful unit of the ITouYing game concept. The close-end survey data is input to an Excel worksheet. The data is grouped into categories according to the gender, department, school location, daily internet access time, daily gaming time. Student's t-test is used to check whether the gender, school location, department, daily internet access time, or daily gaming time are significant factors that influence their attitudes toward the ITouYing game.

10. Findings

The ITouYing game concept survey results are listed in Figure 18. Figure 19 shows the agree vs. disagree in the **ITouYing** survey results. From the survey results, this study concludes that the ITouYing game can enhance participant learning effectiveness in learning orthographic projection (agree 74.9%; strongly agree 15.8% and agree 69.1%). The ITouYing game can promote participant visualization skills between isometric view and multi views (agree 79.9%; strongly agree 18.7% and agree 61.2%). The IToYing game is easy to use (agree 73.4%; strongly agree 18% and agree 55.4%). The rules of the ITouYing game are reasonable (agree 69.1%; strongly agree 18%, agree 51.1%). After data analysis, this study finds that there are significant gender differences only in the 13 items among the ITouYing game concept survey (illustrated in Table 4). Female students feel they are happy to introduce the ITouYing game to their friends and classmates, but male students do not. Moreover, this study finds that there are significant differences in school characteristics (illustrated in Table 5). Students from the industrial education department at National Changhua University of Education perceive the ITouYing game can motivate to learn orthographic projection. Also, the ITouYing game is perceived as able to enhance visualization skills between isometric view and multi-views. The results showed the opinion that the ITouYing game aesthetics are beautiful. The participants also felt the ITouYing game is easy to use and playing ITouYing is fascinating. They agreed the design of the ITouYing game is creative and they would like to introduce the ITouYing game to their friends and classmates.

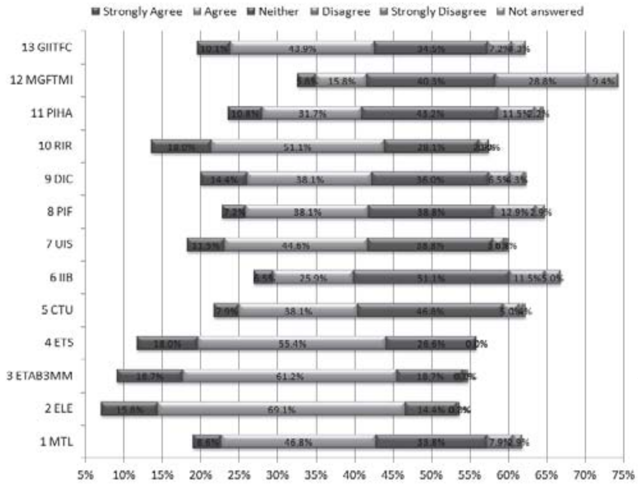


Figure 18: Game concept survey results

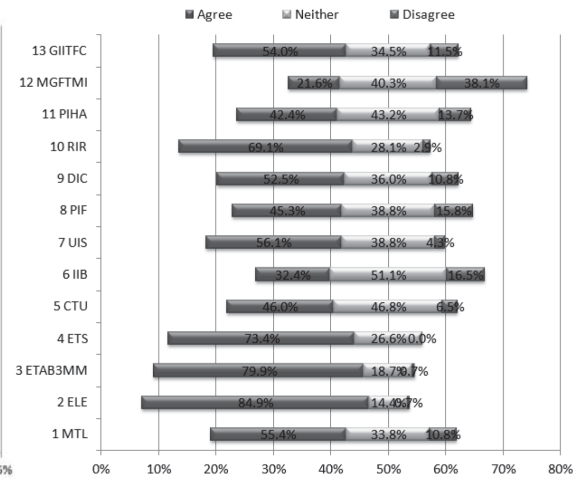


Figure 19: The agree vs. disagree result

Table 4: Significant gender differences among the ITouYing game concept survey

Problem NO.	M-mean	F-mean	M-SD	F-SD	M-Variance	F-Variance	P value (two-tail)
13 GIITFC	2.61	2.22	0.94	0.76	0.88	0.54	**0.0344***

Table 5: Significant differences in school characteristic among the ITouYing game concept survey

Problem NO.	NCUE-mean	NCKU-mean	NCUE-SD	NCKU-SD	NCUE-Variance	NCKU-Variance	P value (2-tail)
1 MTL	2.00	2.55	0.59	0.88	0.31	0.76	0.0034**
3 ETAB3MM	1.62	2.02	0.59	0.66	0.26	0.41	0.0178*
6 IIB	2.08	2.89	0.74	0.88	0.58	0.75	0.0022**
7 UIS	1.92	2.39	0.65	0.79	0.41	0.63	0.0268*
8 PIF	2.27	2.70	0.59	0.92	0.36	0.83	0.0206*
9 DIC	1.77	2.51	0.74	0.77	0.53	0.94	0.0035**
13 GIITFC	1.92	2.59	0.68	0.92	0.41	0.80	0.0035**
	* P < 0.05		** P < 0.01				

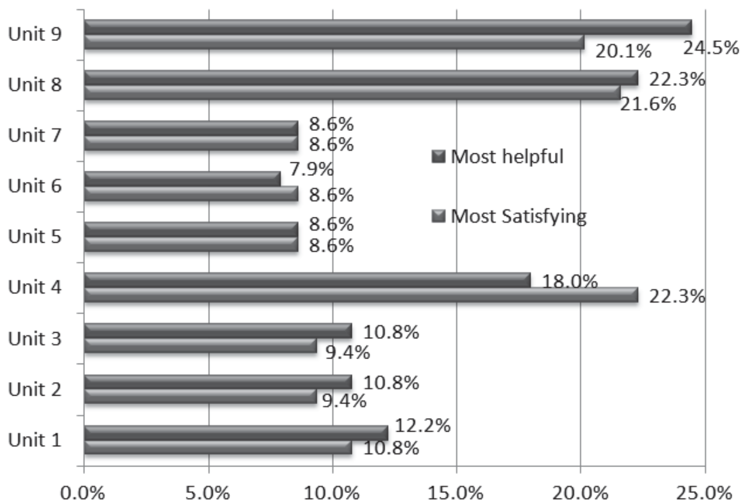


Figure 20: The most helpful unit and the most satisfying unit

11. The most satisfying unit and the most helpful unit

According the open-end questionnaire data analysis, the most satisfying unit is unit 4 (22.3%). The participants perceive that the stain in plane unit is most satisfying for learning orthographic projection. The second most satisfying unit is unit 8 (21.6%), where three views match is tested according to the given isometric view. Furthermore, the participants perceive that the proper 3-D selection unit (unit 9) is most helpful (24.5%) for learning orthographic projection and units 8 (22.3%) and 4 (18%) are also helpful in learning orthographic projection. The detailed results are illustrated in Figure 20.

12. Conclusion

From the ITouYing survey results, there are some advantages of the ITouYing Game, including: 1) ITouYing enhances student visualization skills between isometric view (or 3-D model) and multi-views. 2) ITouYing improves effectiveness in learning orthographic projection. 3) ITouYing is easy to use. 4) The rules (game mechanic) of ITouYing are reasonable. 5) The design of ITouYing is creative. 6) Playing ITouYing is challenging. 7) ITouYing motivates students to learn orthographic projection. On the other hand, there are some disadvantages of the ITouYing Game, including: 1) The images of ITouYing are not very pleasing and can't catch the male students eye. 2) Playing ITouYing is less fascinating, there is no story in it. 3) Playing ITouYing is not high achievement. 4) Playing ITouYing is not smooth. 5) Participants don't strongly recommend ITouYing to their friends and classmates.

13. Discussion and suggestions

Only 30.9% of the students can master both the isometric view and multi views. This approach has high potential to design an innovative serious game for learning orthographic projection. The Digital Native students had previously experienced many beautiful, fascinating, and charming video games. How to design an attractive serious game for educational purposes is a tough mission for Digital Immigrant teachers. The serious game design team should recruit Digital Native members who have expertise in visual arts, visual communication, visual effects, and animation skill to match the learning preferences of the Digital Native students. The participants come from two universities in Tainan and Changhua city from southern Taiwan, so the findings and conclusions of this study may not be generalized to all universities in Taiwan. Furthermore, for more completeness, the IToYing game should broaden the scope of the survey by including participants from different departments, such as industrial design, interior design, product design and architecture. Moreover, participants from different universities, such as the Universities of Technology, Universities of Science, and University of Applied Sciences, should be included.

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Game Design for Transforming and Assessing Undergraduates' Understanding of Molecular Emergence (Pilot)

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Abstract. Undergraduate biology students lack an understanding of the emergent nature of molecular processes and systems and often think about molecular interactions in a teleological manner. A game has potential to transform students' misconceptions through immersion in an interactive environment and through challenges that encourage cycles of productive negativity. The purpose of this pilot study was to test the pedagogical effectiveness of the current game prototype, *MolWolds*, in facilitating conceptual change about molecular emergent systems and to document changes to be made to its design before further trials. Twenty-four first- (n=8), second- (n=9), and third- (n=7) year undergraduate biology students answered two short answer questions about vesicular formation before and after playing *MolWorlds* for 20 minutes. Answers were coded for emergent-themed statements on randomness, concentration, rate/probability, specificity, and crowdedness. It was found that second- and third-year players generated significantly more emergent statements (p=0.011; p=0.018) on the post-test, and first-years (novices to molecular biology) also generated more statements, though the result is only trending (p=0.111). This improvement may be due to engagement in cycles of productive negativity during gameplay: a significant proportion of players (20 out of 24; p=0.001) engaged in one or more cycles, though our small sample did not allow us to make comparisons between groups that did and did not experience this. Generated post-test statements were significantly correlated with gameplay efficiency ratios (p=0.039, r=0.424) and had a trending correlation with total game score (p=0.142, r=0.309), suggesting that gameplay performance might be used to predict conceptual understanding. This study was limited by our small sample size, rendering us unable to perform more robust analyses, such as multivariate regression models. Overall feedback for the game was positive and provided us with several leads for further development and improvement of the game mechanics. Future research will explore how learning through *MolWorlds* differs from learning through a similar non-game control application, how patterns of interactions and demographic characteristics are related to these learning outcomes, and how long-term concept retention is affected by gameplay.

Keywords: molecular emergence, game-based learning, conceptual change, productive negativity

1. Introduction

1.1 Background

Emergent systems (such as ecosystems or molecular environments) involve randomly driven, probability-based phenomena wherein the processes observed must be explained by the simultaneous, independent and collective interaction of all components. In molecular biology, students have difficulty understanding how random, seemingly inefficient, mechanisms contribute to the functioning of complex, perceptually efficient, cellular systems and often compensate by attaching agency, or directedness, to molecular players (Chi & Roscoe, 2002; Chi, 2005; Chi et al., 2012; Garvin-doxas & Klymkowsky, 2008; Jenkinson & McGill, 2012; Slotta & Chi, 2006). It is important that students are able to reconcile randomness at the molecular level with the perceived efficiency of cellular systems as this lends meaning to more complex concepts, such as concentration gradients, protein specificity, or cell signalling.

Animated representations are often used, with mixed results, to portray the events occurring within these visually rich environments. While animations may be successful at capturing the complex dynamics occurring at the molecular level, the temporal and narrative nature of this medium may contribute to students' teleological or goal oriented misinterpretation of molecular interactions. Our lab's research to-date measuring the efficacy of highly realistic, simulation-based molecular animation would suggest that this is the case (Jenkinson & McGill, 2012; Jenkinson & McGill, 2013). A conceptual change is needed. In order to overcome such misconceptions, it is required that 1) the student recognizes that their mental model does not fit and that 2) a *new schema* be built to support the new mental model (Chi, 2005). However, research has shown that the student cannot simply be told that their concepts are incorrect; an active learning experience is needed where the student is confronted with their misconception and is self-motivated to reconcile it (Chi, 2005; Mitgutsch & Weise, 2011; Modell et al., 2005).

Here is where a game can potentially be transformative; games are engaging spaces for active learning that may provide the student with the motivation needed to trigger conceptual change. Video games enhance motivation and engagement with their narratives, challenges, goals, incentives, and competitive elements (Westwood et al., 2010). They facilitate learning with well-scaffolded problems, just-in-time feedback, and opportunities to fail without real-world consequences (Gee, 2007; Landers & Callan, 2011; Squire, 2013). Cycles of productive negativity encourage schema building and are common in gaming environments – the player is challenged by a task and, under her current conception, she fails and must restructure her understanding in order to succeed (Mitgutsch & Weise, 2011; Mitgutsch, 2012). These game design mechanics and elements have potential to increase a student's willingness to participate in meaningful and intellectual play, thereby enhancing his or her understanding of target content and concepts (Gauthier et al., 2015; Gee, 2007; Squire, 2011; Steinkuehler & Squire, 2012).

Until recently, the pedagogical value of digital learning games, especially in STEM fields, has remained largely untested (Annetta et al., 2011; Jaipal & Figg, 2009). New research uses evidence-centred design approaches to A) design serious games, and B) evaluate knowledge through gameplay interactions in combination with educational data mining techniques. For example, Halverson and Owen (2014) linked gameplay efficiency ratios (described as successful game cycle completions over cycle attempts) to learning of stem cell laboratory procedures with high school students. In a recently published study, our lab used evidence-centred design to create two equivalent vascular anatomy study aids (one game and one non-game) for medical students to use informally over the course of a semester (Gauthier et al., 2015). Though learning differences did not differ between groups, multivariate models revealed that "study aid success rate" (a modified version of efficiency ratios that compensates for variability in usage) was a significant predictor of learning in the game group but not in the control group. Further data mining linked game mechanics (such as rules surrounding direction of travel) to this difference in assessment capability.

More research of this kind is needed to enhance the robustness of this field. Additionally, to the best of our knowledge, serious games have not been developed to tackle misconceptions of an emergent nature – this will be one of the first research programs designed to accomplish this.

2. Research objectives

The purpose of this pilot study was to test the effectiveness of our gaming environment (*MolWorlds*) in influencing students' conceptual understanding of the molecular world and to identify areas for improvement in game design. I expected that, through cycles of productive negativity in game play, students would gain a greater appreciation of the emergent nature of molecular processes. Furthermore, participants who gain a better understanding of this emergence would perform better in the game and would achieve greater overall performance in the game measured by score and efficiency ratios, allowing us to use game data to interpret understanding.

3. Description of game prototype

MolWorlds is simulation-based, platform-genre game for use on desktop. In the game, players travel through a molecular realm and experience cellular processes (e.g. vesicle formation) while manipulating properties of the simulated emergent system (e.g. through temperature, macromolecular crowding, concentration) in order to reach their destination. In this initial prototype, three levels were available to play requiring approximately 10-20 minutes to complete. The level design encourages opportunities of productive negativity wherein, under the misconception of directed molecular motion, the player is required to re-evaluate their actions (e.g. increase concentration of a particular protein) in order to compensate for random motion and increase their chances of a desired binding event. The challenges were designed to encourage reflection on concepts such as concentration, specificity, rate and probability of interactions, random motion, and molecular crowding (i.e. environmental complexity). Figure 1 depicts a screenshot from levels one and two.

4. Participants

Participants were 24 undergraduate students enrolled in biology courses BIO152 (n=8), BIO206 (n=9) and BIO372 (n=7) at the University of Toronto Mississauga. BIO152 – Introduction to Evolution and Evolutionary Genetics, is a first-year biology course with a focus on organism diversity; molecular biology concepts are not covered as a topic in this course. There is also a highly diverse mix of students in this course, ranging from students majoring in Biology, to Anthropology, to the Arts. Therefore, this group represents novice learners with high school-level education, providing us with a baseline. In the second-year course, BIO206 – Introduction to Cell and Molecular Biology, students are introduced to molecular concepts and processes such as biology's Central Dogma and various other cellular processes; these students represent the game's targeted audience. Finally, BIO372 – Molecular Biology, is a third-year course that covers more advanced concepts in molecular biology and represents an advanced learner group.

These students have relatively low video gaming habits; on average, they play games between two times per month and once per week on mobile devices, and between a few times per year and two times per month on other platforms. There are no differences in gaming habits between groups.

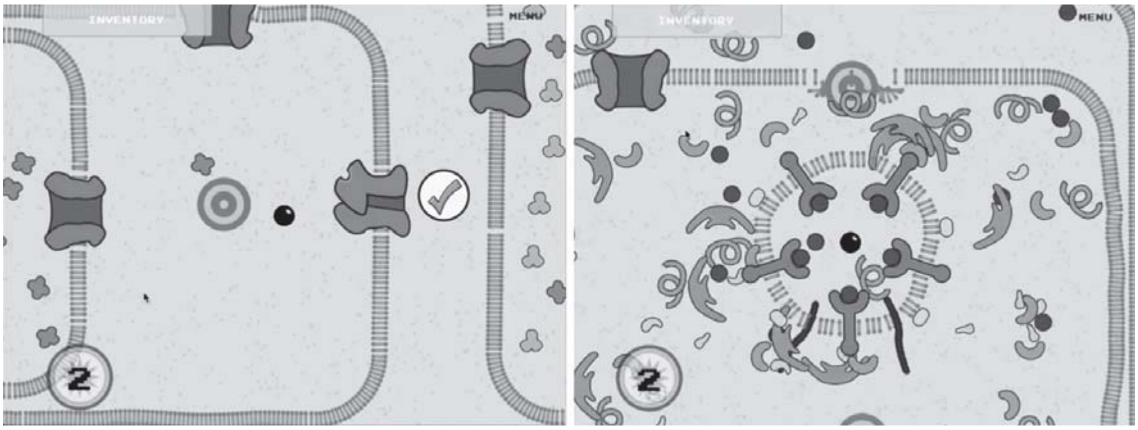

Figure 1: Gameplay screenshots**.** Left: Screenshot of Level 1 gameplay in progress. Player (black dot) has released one ligand molecule (blue) expecting it to bind directly to the membrane channel (green) under their current understanding of directed motion. Right: Screenshot of Level 2 gameplay in progress. The player has successfully encapsulated himself in a clathrin-coated vesicle to be transported across a membrane into Level 3

5. Procedure

Students were invited to the Biomedical Communications laboratory where they were told that the purpose of this study was to test the educational effectiveness of our molecular biology game – they were not informed about common misconceptions regarding molecular motion so that they would not be primed to respond to answers in a particular way. We first asked them to read a one-page description about vesicle formation taken from the BIO206 curriculum course textbook to ensure that everyone had the same baseline knowledge. After reading, participants completed a two-question, short-answer pre-assessment. The first question asked them to describe the process of vesicular formation in their own words and emphasized that the participant should "*attempt to describe everything that happens to the molecules in each discrete step (e.g. behaviour, direction of motion, other interactions)*". The second question asked about factors (environmental or otherwise) that might influence the process of vesicular formation in a real cell. Participants then played the *MolWorlds* prototype for a period of 20 minutes. Telemetry data on their in-game interactions (such as score, levels completed, collected molecules, information accessed, and power-ups used) were recorded into a database. Finally, participants completed a post-assessment that comprised the same two original questions along with their original answers for reference. Participants were asked to review the question and their response and then to modify their original answers as they saw fit. Additionally, students were asked about what they felt they learned through gameplay, what they liked about the game, and what they disliked.

Pre- and post-assessment answers were coded for statements on themes of randomness, concentration, rate/probability, specificity, and crowdedness, all of which relate to emergent processes. For example, in response to question number two (factors affecting vesicular formation), one third-year student answered in the following way prior to gameplay: "*The availability of cargo molecules will affect what vesicles can form and what can be contained within them.*" This answer was coded as one statement on specificity, since the phrase contains only concepts related to the presence of specific types of molecules (not about concentration and how it may relate to probability, etc.).

On the post-assessment, the same student answered: "*The concentration of the specific proteins and cargo molecules will effect how fast the vesicle can form, because these components have no sense of direction and* *move with random motion. As well the temperature of the environment can either inhibit or enhance this process. Heat causes molecules to move at greater speeds thus increasing the likelihood of correct collisions.*" Seven emergent-type phrases were coded in this paragraph. Two are related to specificity ("specific proteins and cargo molecules", "correct collisions"); one phrase ties in specificity with concentration ("The concentration of specific..."); one about randomness ("…move with random motion"); and three about rate and probability ("…will affect how fast the vesicle can form", "Heat causes molecules to move at greater speeds", "increasing the likelihood of…").

6. Preliminary results and discussion

6.1 Emergent statement production

Pre-post comparisons were made with two-sided Wilcoxon signed rank non-parametric tests. First-year participants generated a mean 1.50 (standard deviation (SD)=1.31) emergent statements on the pre-test and 3.63 (SD=3.34) statements on the post-test, a trending improvement (p=0.111). Second-years generated an average of 1.11 (SD=1.27) statements on the pre-test and 5.67 (SD=5.12) after gameplay, a significant improvement (p=0.011). Third-years produced 1.14 (SD=0.90) statements prior to gameplay and 6.00 (SD=4.02) statements after gameplay, also significant (p=0.018). Figure 2 summarizes these findings.

More granularly, we see significant improvement in most themes, including concentration (p=0.001), randomness (p=0.004), rate/probability (p=0.001), proximity/orientation (p=0.039), and crowdedness (p=0.003). Trending improvement is seen in statements regarding specificity (p=0.142), since this category was the most expressed on the pre-assessment (mean 0.62 statements, in comparison to the next highest mean of 0.25 for speed of motion).

Third-years were significantly more likely than first- (p=0.007) and second- (p=0.022) years to generate statements related to proximity and orientation on the post-test, driving the significant improvement seen in the above statistic. Only trending differences were found between groups for other categories.

6.2 Gameplay statistics

Our levels were designed to encourage instances of productive negativity, thus facilitating conceptual change and learning. In Level 1, four students appeared to understand the concept of concentration and randomness from the start, releasing a high concentration of molecules in order to elicit a desired binding event with a ligand-gated membrane channel to complete the level. However, twenty out of twenty-four participants (a significant proportion p=0.001, chi2=10.667) exhibited an action indicative of the misconception of directed motion: they released only one or two molecules, perhaps expecting the ligand to bind directly to its complementary channel. For seven of these individuals, the binding event was successfully achieved, regardless, if the molecule moved quickly (though randomly) in proximity to the channel, or if the player patiently awaited binding. For the remainder of this group, a cycle of productive negativity occurred wherein the player, reflecting on this randomness, collected more molecules to release to increase the probability of a binding event. A similar cycle was also set in motion in Level 2, where players had to collect cargo molecules and release them in an area where cargo receptors were present. Twenty players made multiple trips to gather and release cargo, thus increasing the concentration and binding probability. Unfortunately, our small sample does not allow us to make comparisons between groups that did and did not experience these cycles.

First-years scored a mean 207.50 points (SD=156.98, min=80, max=433), second-years a mean 396.89 points (SD=211.73, min=99, max=687), and third-years 175.14 average points (SD=125.21, min=87, max=441). Second-years obtained a significantly higher overall game score in comparison to first- (p=0.024) and third- (p=0.051) year students. This group attempted the second level (the one involving vesicular formation) significantly more than their younger (p=0.003) and older (p=0.012) counterparts and, as a result, these players were able to complete the level in less time than those in the other groups (p=0.058), thus earning higher scores. We can suggest that this may be because they are actively learning the material in the classroom, so less time is required to learn about individual molecules and more time can be spent on achieving game goals. Furthermore, we see that third-year students scored the lowest of the three groups but responded with the highest number of emergent statements post-gameplay. Perhaps the interaction between gameplay and prior knowledge benefited these students regardless of how well they performed within the game.

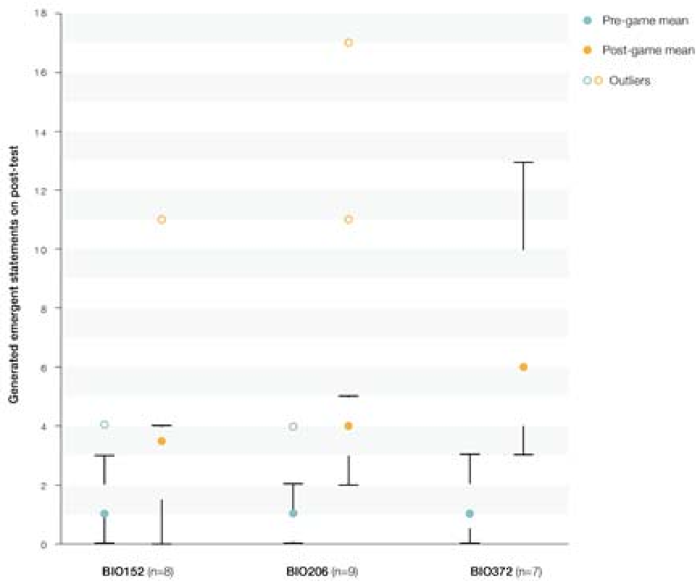

Figure 2: Change in generated emergent statements from before gameplay to after gameplay**.** Twenty-four (24) first-, second-, and third-year biology students first answered questions regarding molecular processes, played MolWorlds for 20 minutes, then revised their answers. Qualitative answers were coded for emergent-type statements (themes of randomness, concentration, rate/probability, specificity and crowdedness). Significant increases in statement production from pre-gameplay to post-gameplay were observed in second- (p=0.011) and third- (p=0.018) year groups. Trending improvement was seen in the first-year group (p=0.111)

6.3 How gameplay statistics relate to emergent statement production

Due to the small sample sizes of our three subpopulations, we are unable at this time to build a comprehensive regression model with our pilot data. However, we have found some interesting non-parametric bivariate correlations (measured with two-tailed Spearman tests at 0.05 significance level) that may be worth further investigation in upcoming work.

We found an overall significant correlation (Figure 3) between generated post-test statements and game efficiency ratio (successful level completions over level attempts) (p=0.039, r=0.424), and a trending correlation between pre-post statement improvement and efficiency (p=0.066, r=0.382). Similar trending results were obtained for game score in correlation with post-test statements (p=0.142, r=0.309) and improvement (p=0.133, r=0.315).

To break this down further, we can investigate players' efficiency ratios in individual game levels. In particular, Level 2 of this prototype is a perfect candidate as this level targets all of the concepts we are interested in, involves vesicular formation, is longer and more difficult than Level 1, and all participants attempted the level at least once. Level 2 efficiency ratios were significantly correlated with overall statement production (p=0.010, r=0.515) and statement production improvement (p=0.007, r=0.532). More specifically, participants' efficiency ratios in Level 2 were significantly correlated with statement generation about concentration (p=0.053, r=0.399), speed of motion (p=0.008, r=0.525), and probability (p<0.001, r=0.676). Only ratios for BIO206 players' correlated with statement generation about randomness (p=0.015, r=0.770). This indicates that our level design may need to be tweaked (or new levels should be specially created) that put more focus on other aspects of emergence (for example, proximity and correct orientation of molecules during a binding event).

These correlations suggest that gameplay performance may be indicative of conceptual understanding and, if included in a more comprehensive multivariate model, may prove to be significant predictors of this. Efficiency ratios from individual levels might be used to assess understanding of particular concepts targeted by that level's game design.

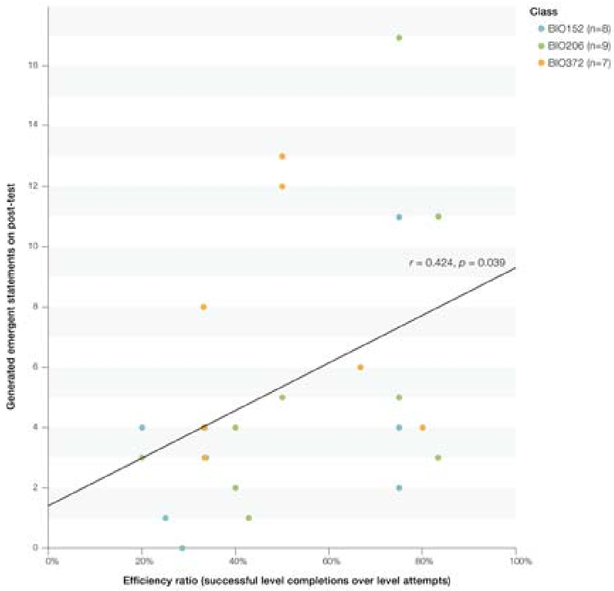

Figure 3: Correlation between students' game level completion efficiency ratios (successful levels completed over level attempts) and generated emergent statements after gameplay. Twenty-four (24) first-, second-, and third-year biology students first answered questions regarding molecular processes, played *MolWorlds* for 20 minutes, then revised their answers. Qualitative answers were coded as stated in Figure 2. A trending correlation is observed between efficiency ratios and emergent statement production, suggesting that the in-game performance may indicates conceptual understanding. The game design will be modified accordingly to enhance this effect

6.4 What players felt that they learned

From our qualitative analysis of players' responses, we can make inferences about how these students conceive the molecular world and how their conceptions changed through playing the game. But what do students themselves feel that they learned? At the outset of the study, we did not inform the students that the game was meant to target emergent concepts, and we were interested to see what students took away from the experience.

Several participants (12 of 24) reflected that their knowledge of vesicular formation was enhanced or solidified. For example, one BIO206 student wrote: *"I have a midterm on Monday. I feel that by playing this game, I have a better understanding of the vesicular formation concept. I now feel that all I need to do is look over my notes one more time. I know the names and functions of molecule components used in vesicular formation [...]".*

Fourteen participants (two first-years, five second-years, and all seven third-years) actually used emergent language in these responses. For example, a third-year student reflects on the difference between their in-game experience and what is usually taught in Biology classrooms: "*I feel I learned about how non-ordered the movements of the proteins in cells actually are. In most classes, we learn a very fixed model of interactions, which is not an actual representation of how a cell works. There are many different molecules in a cell in a fixed space and this game gives you an appreciation of that fact.*"

A first-year student discusses randomness and crowdedness in his response: "*I learned that molecules can affect the movement of other molecules a lot. For example, when I increased the heat a lot, the other molecules were hitting me so hard that I kept flying around uncontrollably and when I chilled the environment I could get the crowded areas much more easily. Also, sometimes I had to wait a while for others molecules to bind to things after I released, and although that was a little irritating, I learned that they don't do it in a set fashion, but rather randomly.*" This is also a great example of how the physicality of a character in a game world can influence learning; instead of passively watching a simulation or an animation of molecular motion and how temperature might affect it, the player is interacting with (and against) these forces in order to reach a goal, which we believe might lead to a more memorable experience.

6.5 What players liked and disliked

Participants had a chance to comment on what they particularly liked or disliked about the game, which will be of value in future game design and development. Responses were very positive and exemplify why serious games make great learning tools. For example, a first-year wrote: "*The fact that it was an interactive game and that you got to move around was a vital component of the game. To me, it felt as though I was playing a maze game except I was actually learning important biology concept. So it felt like I was getting the best of both worlds.*"

Most comments in the "dislikes" section contained helpful feedback for upcoming designs. These include integrating a world map or the ability to zoom in and out and see the level as a whole, the ability to use ASWD keys en lieu of arrow keys to control movement (leaving the right hand free to use the mouse), and adjusting the dynamics of the character so that it is easier to control. Some participants also made detailed description of actions performed that lead the program to "bug".

7. Limitations

This pilot study doubled as a usability trial. Small-scale, informal usability was performed with the prototype beforehand but this was the first time the game was used extensively by target users. As such, we ran into a few programing "bugs" that would need to be addressed before future studies can ensue.

Furthermore, the game score was largely determined by time to level completion to encourage players to make appropriate modifications to the system for a speedy completion. For this to be effective, players should have enough time to reattempt the levels multiple times so that they can build upon their experiences. Unfortunately, some players struggled at the beginning to understand the use of certain game mechanics (e.g. using a slider to select how many molecules to release), resulting in a lengthier amount of time spend learning the game in the initial stages than originally anticipated. As a result, some students did not have time in the 20 minutes allotted for gameplay to replay levels multiple times. In addition, one player's comment in the "dislikes" section may suggest that the scoring method (time-based) may have detracted from the pedagogical value of the game: "*I feel like that the fact that scoring is based on time, takes away from learning about the actual molecular structures involved. The fact that the player has to get a certain task based on time would discourage them from clicking on the receptors or signals and learning more about them*". Perhaps an improvement might be to have two modes (e.g. regular and time trial) to encourage both kinds of interactions.

Our written assessment format also had its limitations. We opted not to use direct questions such as "Do you believe molecular motion to be random or directed?" in order not to prime them for the intervention. Through the use of these short answers, we were able to identify teleological use of language, such as "*adaptin molecules guide cargo*", "*where the vesicle wishes to go*", and "*the cargo has trouble finding its receptor*", though this type of language was found both on pre-assessments and post-assessments. It is difficult to say whether it means that students actually think that these molecules have agency or whether they are simply using this language to tell the "story" of vesicular formation. Regardless, it is clear that emergent-type thinking and language was used to a much greater extent after gameplay. Future studies should investigate other means of written assessments.

8. Conclusions and future directions

This pilot study suggests that, at the very least, students are more aware of the emergent qualities of molecular systems after gameplay, reflected in the significant increase in emergent statement production. Results demonstrate a significant relationship between game performance (measured in efficiency ratios) and emergent statement production, which suggests that the game's evidence-centred design framework that encourages instances of productive negativity is achieving its assessment capabilities. Several areas of improvement in game design were identified.

Our future research builds upon preliminary results with a longitudinal study that assesses participants' misconceptions 1) at the beginning of the school year, 2) after a semester of biology instruction and gameplay intervention, and 3) eight months later. Learning outcomes for individuals playing the game will be compared to those who interact with a non-game interactive simulation (control) application containing the same learning material. Gameplay data will be collected remotely and machine learning software (e.g. WEKA (Hall et al., 2009)) will be used to determine how specific sequences of gameplay interactions (e.g. sequences of productive negativity, use of power-ups, etc.) relate to conceptual change.

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Novices Vs. Experts; Game-Based Learning and the Heterogeneous Classroom Audience

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Abstract: This paper examines how the heterogeneity of K-12 students, as game audiences, affect the way games can be used as educational tools in formal education. When discussing the application of games in educational contexts, the realities of the formal educational environment are seldom brought to the fore. There has been a lot of discourse and studies surrounding the theoretical viability of games as engaging educational tools and their properties as learning environments, but the practicalities of inserting games into classroom environments are comparatively rarely the subject of game-based learning research. This paper presents two five month long studies using participatory observation that details the process of putting a commercial of-the-shelf game to use in two different types of formal educational K-12 environments: a computer lab and a classroom. More specifically, this paper focuses on examining how students receive and work with a well-known commercial off-the-shelf game when it is introduced as a tool in their ordinary curriculum work. The study revealed several challenges that put many of the axiomatic assumptions practitioners and scholars frequently make regarding games' virtues as educational tools into question. The challenges relate to students' perceptions of games and gaming, variations in students' efficacy while playing, and of exclusionary behaviour during collaborations. Commercial of-the-shelf games, while they might be more equipped than educational titles when it comes to living up to player expectations as far as production values are concerned, can instil a certain set of faulty expectations of how the game will actually be used. If the used game is widely recognisable by the classroom audience, the important distinction between gameplay intended for active directed learning rather than unguided leisure activity can be difficult to establish, which can make it difficult for teachers to keep students in a reflexive and analytic mode of play. The classroom as a game audience also puts the educator in a tricky position due to the wide variation of preferences and gaming literacy among students, and creating engaging play-sessions that are inclusive to everyone in classroom environments can be an immense undertaking for teachers. While the study reveals several issues produced by the tension between games and the heterogeneous nature of the classroom as an audience, it also highlights the importance of managing students' expectations, framing the play activity correctly, and fostering collaborative work where subject matter knowledge and gaming literacy are intertwined.

Keywords: classroom gaming, alpha gaming, audience heterogeneity, gaming literacy

1. The classroom as a game audience

Games are often lauded for their unique capacity to model the structures of complex systems, distil them down to their essence and present them to the player for him or her to experience and manipulate first-hand (Annetta, 2008; Gee, 2009). They invite the player to form an understanding of intricate subject matters based on participation and experimentation rather than mere observation, and thus they are argued to have great potential as learning environments (Squire, 2011). With these stated benefits of employing games as educational tools, there has been an increasing interest for including more game-based learning in school curricula. A particularly popular argument supporting this movement is that students are starved for an educational format that makes use of their affinity for new technologies (Linehan et al, 2011; Prensky, 2001; Srinivasan, Butler-Purry & Pedersen, 2008).

However, whenever one attempts to lift a game with content that can be used for educational purposes into a formal educational setting, problems start piling up rather quickly (Berg Marklund, Backlund & Engström, 2014; Egenfeldt-Nielsen, 2008). Not only are there inherent conceptual issues with the assumption that increased skill or knowledge regarding the contents of a game has any bearing on the world outside of the game even when the game content is closely tied to a specific subject matter (Linderoth, 2009; Rick & Weber, 2009). There is also the simple, often glossed over, fact that many components need to be in place for even the most rudimentary play session to be made possible in a school environment. Hardware availability, the teacher's grasp of the game, the students' gaming abilities, and the strict schedule limiting the length of the play sessions are but a few of the practical considerations you face when attempting to insert games in formal educational contexts (Egenfeldt-Nielsen, 2008; Squire, 2005).

This paper focuses on examining one of the many factors that come into play when games are placed in formal educational environments: how the heterogeneity of the audiences in formal educational settings affect classroom gaming. The research is based on the results of two five month long case studies conducted in K-12 classrooms, where the researcher collaborated with teachers to integrate and use educational games into their curricula.

2. Fundamental concepts in game design and engagement

To examine how and why the heterogeneity of the classroom audience affects educational games and game-based learning initiatives, a brief review of some key concepts of game design is necessary. The reason why games engage their players, and which designs manage to do so consistently, has been dissected for several decades by many scholars and practitioners (Cowley et al, 2008). Literature discussing serious games and educational games often use the outcomes of this type of game studies to describe why games are a good idea to implement into schools and how different subject matters can be conveyed through different types of designs methods (Annetta, 2010; Franzwa, Tang & Johnson, 2013). The primary design challenge of serious games and educational games tend to be described as a balancing act between maintaining the integrity of a subject matter while simultaneously providing engaging game scenarios (Annetta, 2010; Bellotti et al, 2009). However, good game design is not an objective metric and game designers' intentions mean little if the game is not 'good' in the eyes of the people playing it. This is where formal education becomes troublesome as a setting for gaming; as an audience, the classroom is exceedingly heterogeneous, and a game *needs* to be accessible and engaging to all of its members.

2.1 What makes games 'engaging'?

Csikszentmihalyi's (1990) theory of 'flow' and optimal experience is often used to describe well-designed gaming experiences (Cowley et al, 2008; Sweetser & Wyeth, 2005). Just like rock climbing, ballroom dancing, or the playing of an instrument, or any other activity that has the ability to instil a sense of flow, an engaging game needed to adequately challenge its player while not being imposingly difficult (Chen, 2007; Sweetser & Wyeth, 2005). According to subscribers of Csikszentmihalyi's concepts, an activity that pushes the right psychological buttons can fully absorb its participant, and this realization has been widely applied to game design, both as an object of academic study and as a craft (Cowley et al, 2008; Sweetser & Wyeth, 2005). The 'flow' model that visualises the balance between skill and challenge is one of the more commonly referenced concepts from Csikszentmihalyi's work (see Figure 1).

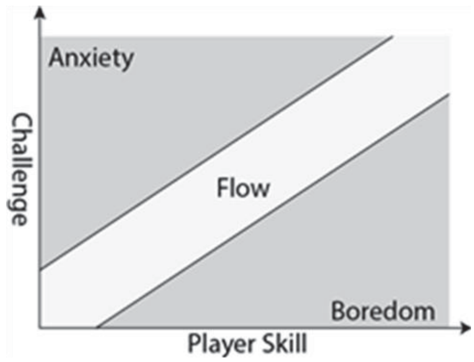

Figure 1: The relationship between challenge and player skill, here a merger of the diagrams presented by Chen (2007) and Csikszentmihalyi (1990).

Since its inauguration, flow has both been used as a template to design good game experiences, but also as a tool for evaluating games and why they do or do not engage their players (Sweetser & Wyeth, 2005).

2.2 The formal and the informal

The central dichotomies between formal and informal application settings are characterized by the circumstance of player participation. A formal setting is characterized by its structure, the obligatory nature of audience participation, and the constraints it places on time and space for the play sessions. A game played in formal settings is often played under supervision of some type of tutor, that it has specific requirements of learning objectives that need to be fulfilled, and that it has a structured time and space allotment in which to do so. More importantly for this paper, however, is that the formal application means that the game has a captive audience rather than an opt-in one. In informal settings these conditions and parameters are not present to the same extent, if at all. This significantly alters the requirements on the games, and puts constraints on what they are allowed to do.

In the case of entertainment games, or educational games that are not bound to a specific educational context (e.g. games with educational elements purchased for home use), the audience are opt-in consumers and the developer has the creative license to focus their game aesthetics to resonate with a certain type of individual. In these cases, developers are not obligated to cater to everyone, and the consequences of focusing their product only means that the consumers that are not attracted to the game concept and engaged by its contents simply will not purchase the game. Games that are to be used in formal education however, have far more intense requirements of audience appeasement – and a more heterogeneous audience they need to appeal to. The outcomes of the studies presented here highlights why this can be problematic, and what the implications are for educational game design.

3. Method

This section briefly covers the methods of data gathering, and the different premises of the classrooms and game-based learning projects in which the studies were conducted.

3.1 Data gathering methods

This research focuses on understanding how games actually work within their intended real-life context of use. To that end, this research has employed a case study methodology during two game-based learning projects spanning from November 2014 to March 2015. The reasons for choosing to conduct case studies is that they afford an opportunity to examine a contemporary, perhaps not fully detailed previously, phenomenon in its real-life context (Robson, 2002; Yin, 1984). In order to create the "full body of evidence" (Yin, 1984 p.24) needed to build a comprehensive understanding of the studied context, the research employs a mixed-method approach employed on multiple cases. The primary methods used during the case studies conducted for this research have been participatory observation protocols, transcriptions of classroom gaming sessions, and interviews with teachers.

The classroom gaming sessions were documented through the use of a written observation protocol that were formalized to keep track of teacher and researcher interventions, student discussions, and technical difficulties that arose throughout the gaming sessions. Furthermore, and perhaps more importantly for this paper, audio recordings were made during classroom gaming sessions, and the audio was then transcribed to either provide context to events that were mentioned in the protocols and to find interesting events that the researcher missed during their field work.

3.2 Classroom setups and game-based learning project designs

The two studied game-based learning processes consisted of two quite different setups. One case involved students in the 7th grade (ages 13-14) who were all part of a national program that supplied them with one laptop per individual. The other case involved 5th graders (ages 11-12), who had a smaller amount of communal computers to share within their class. The classroom sessions were thus structured differently, as the older students had enough hardware to play games as a whole class (all 24 students could play simultaneously), and the younger students played in smaller groups (dividing 24 students into two groups of 12, that shared six computers). However, even though the high-school class had enough computers to play individually, the teacher often opted to have them work in groups of two, sharing one of their laptops. Figure 1 shows the different classroom setups.

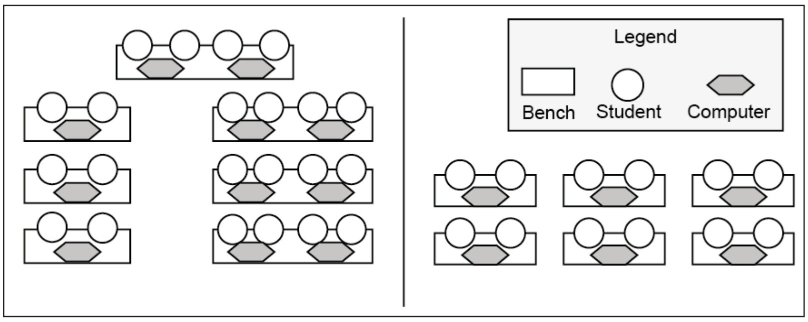

Figure 1: Though the 7th grade students (left) had individual laptops, they were divided into groups of two and shared one laptop. The 5th grade students (right) worked in groups of two on communal laptops.

The two different classes also worked with different subject matters: the 7th grade class worked with mathematics and geometry, and the 5th grade class worked with medieval history. The game used in both subjects was *MinecraftEdu* (TeacherGaming LLC, 2012), which is a version of the game *Minecraft* (Mojang, 2011) that has been modified for use in educational environments. The 7th grade students worked in smaller groups and collaborated on a series of different geometry exercises. The 5th grade students worked with history, and had a longer continuous collaborative project where the class was divided into two groups of 12 to build medieval structures and societies. Examples of what types of gaming activities the two curriculums resulted in can be seen in Figure 2.

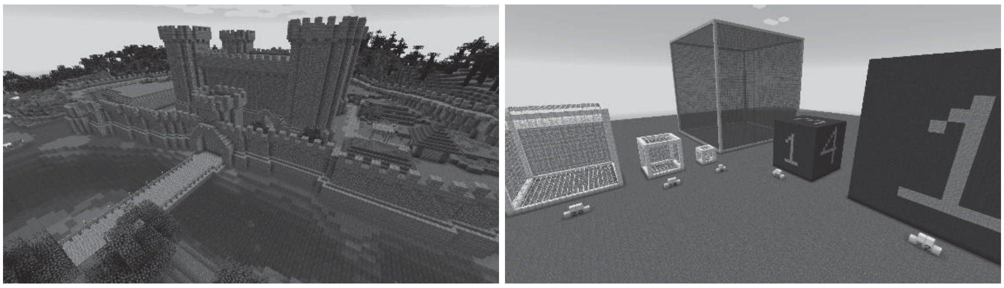

Figure 2: During the history curriculum, students collaboratively built medieval structures and societies (left). During the mathematics curriculum (right), students made calculations, drew blueprints, and built geometric objects and models of real-world objects (e.g. a scale model of a numbered dice)

4. Results

In this section, the differences in the types of players one encounters in a classroom audience will be presented. The section covers a few overarching 'archetypes' of students as gamers, and couples them with examples from the observation protocols and audio transcripts. The implications of these results are later discussed in the conclusion and discussion.

4.1 The spectrum of students as gamers

During classroom sessions, it was evident that students had severely different backgrounds when it came to technological- and gaming proficiency. Some students professed to not only playing *Minecraft* on their own at home, but that they also paid for dedicated servers and created gameplay videos and guides that they put up on YouTube. Simultaneously, the same classrooms also contained students that had never tried *Minecraft*, or any computer game with a similarly advanced interface. For example, during one of the early classroom sessions with the 7th grade students, the observation protocol states that "*A lot of students (around a fourth of the class) still don't know how to start the game or how to play, how to interpret "blocks" as units of measurement, how to choose and place blocks in the game interface, or even how to steer their avatar (the combination of WASD steering and mouse movement is difficult for many), I spend a lot of time running around and managing those issues*." Conversely, transcripts from the same class show that some students are highly proficient:

Excerpt from a 7th grade classroom gaming exercise on February 20th
[Aaron and Sarah are playing together. Aaron is a proficient player, and is showing off his grasp of the game to his classmate]
Aaron: Take this one. And then you use them on the pigs here. Check it! They're making babies!.. And then they fall off.
Sarah: Awh, those pigs are adorable! You're not going to kill them are you?
Aaron: time set one thousand [reading aloud a console command (/time set 1000) he is executing]
Sarah: What do you mean… "set"?
Aaron: Now you'll see something even cuter.
Long pause with mouse clicks
Aaron: Mushroom cows! You know, take 'em, take 'em, take 'em!

Here, Aaron clearly demonstrates that he is a proficient player as he knows console commands for the game, and knows how to access relatively obscure objects in the game. Simultaneously, Sarah has some trouble with the game, and is not familiar with the language Aaron employs, showing the breadth of students' game proficiency. Furthermore, the excerpt also exemplifies a common issue encountered during the classroom gaming sessions – the game proficient students focusing more on showing off and experimenting with game mechanics rather than remaining in an educational frame of play.

4.2 The proficient gamers

While proficient gamers need less supervision in terms of game tutoring, they often require other types of attention and are also prone to display gaming behaviours that can be disruptive in the classroom environment. The proficient gamers are both difficult to engage with educational goals, but they also place much higher demands on the conditions for their gaming.

Excerpt from a 7th grade classroom exercise on February 20th
[Aaron has just started up the game for the class exercise]
Aaron: Oh my god, my latency is super high. Check out my ping!
Aaron: Can you have a look at my latency? [directed towards the researcher]
Aaron: My ping is over a thousand!
[…]
Aaron: But like… I have 1600… my ping is one thousand one hundred and sixty two.
Another excerpt from the same session
Jonas: Minecraft on the highest settings – that's what I'm running at my gaming computer at home. Desktop rig. No lag.
Jonas: Here it lags on the lowest settings.

Excerpt from a 5th grade classroom exercise on February 17th
[Felicia and Miley are playing together; Felicia is an inexperienced player while Miley is an expert. Felicia is commenting on the stacking of chests on top of each other – realistically, the bottom chest *should* be impossible to open.]
Felicia: I don't think they had… um. Chests like that.
Pause
Felicia: I don't think they had the technology to do things like that.
Miley: Whaaat?
Felicia: I don't quite think that they had that technology – like, how are you going to open them?
Felicia: *laughs* … the one that's on the bottom?
Miley: *silly voice* Felicia you can build like that *unintelligible* in minecraaaaaft.
Felicia: *giggles* But if you put a thing down, super close to the other thing that can be opened. why... [Miley interrupts]
Miley: Oh come on, it- it- it- it's lagging! [Miley gets frustrated with the computer's performance]
Felicia: … can you open it? [Felicia finishes her sentence]
Miley: Like it- it- it double-clicks when you only click once…
Felicia: Shouldn't we also put in a monastery citizen?
Miley: … sometimes.

The above transcript excerpts exemplify the demands that game proficient students place on the tools they are given to work with, and if either the provided hardware or software hinders their ability to play the game to their full capabilities their engagement in the educational gaming task often diminishes rapidly. In the example of Miley and Felicia, Felicia kept contextualizing the gameplay in reality (by mentioning how the chests in the game were used illogically). But, as a more proficient player, Miley pays more attention to what the game allows rather than what might correspond better with the life-like environment they are trying to create in the game. Miley's attention to the task is also interrupted as a result of non-satisfactory performance of the hardware.

The proficient players were also often generally displeased with the constraints that the educational goals of the gaming activities placed on their gameplay. The observation protocols note several instances of game proficient students shouting objections like "*this sucks*" when they are informed of what the goals of the gaming activities are, and teachers also frequently noted that the game proficient students were the ones who were most difficult to engage with when it came to discussing details of the taught subject matter. A note in the observation protocol from an exercise with the 5th graders exemplifies this clearly: *"One group of boys, seasoned players, had a tendency to just veer of track and start using the bow and other game elements to pass the time, and show off their skills […] One person in this group was also fairly negative about the process, and I got the feeling that* *the student felt very restrained or constricted by having to work with his peers, and that their plans didn't really mesh with what he had envisioned."*

4.3 The less experienced players

Novice players present a totally different set of challenges during gaming activities. As previously mentioned, a non-trivial amount of students in the classrooms had difficulties grasping fundamental aspects of the game, or even had trouble launching it. Interfaces that some might consider self-explanatory can be hard to decipher for newcomers. The following transcript excerpt is an example of a commonly recurring intervention the researcher had to make during gaming exercises:

Excerpt from 5th grade exercise on February 24th
Juliet: [Talking to the researcher] Ok so… Alright, how do I. Like, how do I find. Like, how do you set out fences like, like *that*
Juliet gestures towards a fence and a fence gate in the game
Researcher: How do you mean?
Juliet: You know, kind of like. A fence that can do like this.
Researcher: Oh, ok! That's actually not a piece of fence, it's a gate.
Juliet: Oh!
Researcher: So you have to go in here, and pick this. [The researcher shows the item in the inventory menu]
Juliet: Ah.
Researcher: And there we go, there it is.
Juliet: Where is it?
Researcher: There we go. And then you put it down like that.
Juliet: Ok.

It should also be noted that this example is not taken from an exercise early on in the game-based learning project, the students had at this point spent four sessions playing the game (totalling around six hours of game time). It was also not an isolated case, and other groups of students frequently needed help navigating the interface of the game. Another common issue is that the less proficient player finds the gaming activity boring or pointless, either because the game proficient student 'takes over' the activity, or because they feel frustrated by the difficulty of the task:

Excerpt from 7th grade exercise on February 27th:
Anne: But like… this is boring as sh*t.
James: Not… not for me, because I know how I'm going to build. Check this out. [James then proceeds to invent a lava-based animal-murdering machine]
Excerpt from 7th grade exercise, 20th of February:
[The students are working with the scaling of area and volume]
Researcher: Are you building a cube each?
Sarah: No! I'm going around killing pigs.
Researcher: Alright, have something happened?
Sarah: Not really. First we started working on mine, but then he wanted to, um… do things his way.
Researcher: Oh, but this pink shape you have, is that one of your versions at least?
Sarah: Mhmmm. I worked on that one.
Researcher: So that's your Area-version?
Sarah: Yes, that was mine.
Aaron: Nooo, I need to get one that has Strike [Strike is an enhancement for weapons that increase their damage]

5. Conclusion and discussion

From studying two five month projects of game-based classroom gaming, severe differences in students' proficiencies, preferences, and approaches to gaming could be seen. The heterogeneity of the average classroom constitutes a fundamental problem for educational games. Both proficient and novice students presented their own set of specific challenges, and it is difficult to construct exercises that will engage proficient students while still being inclusive to the novices.

The findings of this study fall well in line with a similar study conducted in 2008 by Egenfeldt-Nielsen (Egenfeldt-Nielsen, 2008). In an attempt to use the complex historical strategy game *Europa Universalis II* (Paradox Development Studios, 2001), his study revealed severe differences in how quickly students were able to learn the game, some spending several weeks trying to grasp the basics of the game's interface. For these students, just getting to the level of expertise needed to interact with the content meant to teach the subject matter consumed several valuable classroom-hours (Egenfeldt-Nielsen, 2008). Instead of being able to discuss the subject matter, teachers also had to spend a significant amount of their student-teacher time teaching the students how to play instead. Granted, *Europa Universalis II* is a complex game, but it is unlikely that reduced complexity and difficulty in educational games is a solution to the problem. For example, *Minecraft* is arguably a much more accessible game than *Europa Universalis II*, but the gaming activities in this study was still beset with the same issues that Egenfeldt-Nielsen encountered. This shows that games do not have to be overly advanced in order to make classroom gaming problematic.

This has some implications on the concept of 'digital natives' that is still prevalent in the game-based learning community. While some scholars and practitioners maintain that everyone born after technology and connectivity had become ubiquitous have an innate ability to grasp technological interfaces and a desire to engage with them (Annetta, 2008; Prensky, 2003), placing a game in front of a classroom of students quickly reveals the spuriousness of those claims. From the participatory observations, and analysis of transcripts from classroom gaming sessions, the students were not found to share an innate affinity or desire for interacting with technology interfaces. The proficient students often found gaming activities too trivial and constraining, while the novice students often found it intimidating or frustratingly difficult. This often complicated the game-based learning process, as creating assignments that simultaneously cater to the students who have trouble controlling their avatar and the students who are very game proficient (and get bored by too trivial gameplay) is a very difficult task.

These problems are further ratified by the principle of 'flow' in games. If player engagement depends on the relationship between the intensity of game challenges and player skill, and if player skill varies greatly in your intended audience, creating an engaging game becomes difficult. Fundamentally, a classroom audience is spread all across the X-axis of the 'flow' model (see Figure 1). But, there are also several parameters other than player skill that dictate game enjoyment and that varies greatly between individuals in a classroom as well (Kickmeier-Rust et al., 2011; Squire, 2003). For these reasons, creating an engaging learning game for classroom environments is difficult, and unless the classroom is homogenous (e.g. private schools, specific summer schools, or schools focused on training specific skills) or if the game is highly adaptive, a significant amount of students may rapidly become disinterested in the educational game experience. But, as noted by Egenfeldt-Nielsen (2008) and Squire (2005) in their studies on the implementation of educational games in classrooms, failing to motivate is not the only challenge of catering to these environments. Time spent on mastering game mechanics, for instance, is time taken away from learning the subject matter (Macklin & Sharp, 2012; McClarty et al., 2012; Squire, 2005).

This paper shows that the integration of a game into a classroom – even one as popular as *Minecraft* – is difficult, and no guarantee for student engagement. By close supervision and guidance from the researcher and the teachers, the gaps between the students could be smoothed out over time. But, it is important to recognise that access to an extra set of game-proficient hands and eyes is not a common occurrence in classrooms, and is mostly a privilege exclusive to schools that engage in research initiatives or special programs. The implications of this research are that games might not be the golden tickets to student engagement that some scholars and practitioners claim. Games, just as any other educational tool, requires a great deal of investment and hands-on guidance from teachers, who needs to continuously anchor gameplay in an educational framework and tutor novice students in how to work with a game's interface.

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Gamification for Data Gathering in Emergency Response Exercises

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Abstract: Our paper describes how gamification can be implemented in an emergency response exercise. In particular, we focus on the potential of gamification to support self-evaluation processes through the automated gathering of data about the participants' performance. Disaster-exercises are typically constructed around a scenario posing more or less known challenges to the participants, with the performance often determined only by observation. While these observations certainly have a value in their own right, since participants are deeply engaged and immersed in such exercises (e.g. detailed descriptions of events, immediate interpretation of data, and placing results in context) they also have their limitations. Especially in regards to learning in emergency response exercises we encounter limitations due to the observer's cognitive limitations and the (limited) type of data that is being gathered. While external observations may be sufficient for evaluation the execution of tasks according to pre-determined standards, less well defined and complex processes, such as decision making processes, are more difficult to evaluate. Such processes are for example influenced by cognitive biases, group dynamics and even political motives. Finally, on a more practical level, the dependence on external observers adds an additional requirement to already resource-intense disaster exercises, especially considering the required expertise. We aim to demonstrate the potential of gamification in disaster exercises to support the structured collection of data regarding the performance of the participants. This data would support self-evaluation, in turn reducing the dependence on external observers and provide additional insights. First we derive different constructs from the various learning objectives associated with complex tasks such as group decision making, coordination and building situational awareness. Next we translate these constructs in quantifiable measurements enabling data collection. Finally, we implement these measurements in gamification elements in a disaster exercise game. The resulting data is presented to the participants enabling them to reflect on their own performance as a team reducing the dependence on external observers. This concept has been explored, developed and studied in an experimental setting. Ten volunteers were involved in the study, participating in a simulated emergency response exercise at the University of Amsterdam. In this test the focus of the exercise and the implemented gamifications elements were the decision making process, information management and coordination efforts. For validation purposes, the participants were divided over three different groups each given the same tasks and challenges. Additional several experts in disaster exercises and decision making were present to compare the outcome of the groups' self-evaluations with their notes as 'traditional' observers. Our results indicate that gamification can be a strong tool to gather quantitative data concerning the learning goals of the exercise that in turn helps participants to evaluate their own performance for complex tasks during disaster responses. Participants were to a large extend able to indicate the same lessons as the observers. Demonstrating that the collected data supported the participants to reflect on their performance and identify improvements themselves. Moreover, participants also indicated additional lessons learned which were not noted by the observers.

Keywords: gamification, quantitative measurement, data gathering, decision making, disaster exercises

1. Introduction

Emergency response exercises often have a high degree of interaction between the elements that have to be learned. This increases the natural complexity of the information that must be understood and the material that must be learned (Sweller, 1994). However, the achievement of learning goals is often only determined by observation. These observations are certainly valuable in their own right (e.g. detailed descriptions of events, immediate interpretation of data, placing results in context). However, solely using observations to gather data has its limitations (Kanat, Siloju, Raghu & Vinze, 2013). The limitations which are most relevant regarding learning in emergency response exercises are the observer's cognitive limitations and the (limited) type of data that is being gathered.

Observers are often tasked to observe areas with multiple trainees, which is in contrast with the observers' natural tendency to focus on a specific trainee or groups of trainees (Capgemini, 2008). The problem is that the observer has to divide and prioritize attention, thus a limited amount of data can be gathered when multiple targets have to be observed for prolonged periods of time. This is known as limited retainment of information (Mook, 2001). It would be impossible for the observer to accurately recall all events from the last few hours. This can have a detrimental impact on the quality of evaluations. Furthermore, the use of observers introduces the factor of subjectivity for example based on their own expertise, experience or background. This might lead to an inaccurate or incomplete description of events (Scholtens, Jorritsma, & Helsloot, 2014). Next observers, can only rely on observable facts unless they disrupt the exercise (immersion) of the participants by asking questions, introducing a bias to results. For example, a clarification question from an observer might trigger unwanted behavior from participants such as correcting or reconsidering their current actions or decisions. Finally, on a more practical level, the dependence on external observers adds an additional requirement to already resource-intense disaster exercises, especially considering the required expertise.

Generally speaking, gamification has the potential to aid in the gathering of quantitative data. Gamification is the use of game elements to improve user experience and user engagement in non-game services and applications (Deterding, Sicart, Nacke, O'Hara & Dixon, 2011). In particular, we focus on the potential of gamification to support self-evaluation processes through the automated gathering of data about the participants' performance. One of the most common implementations of non-intrusive game elements for data gathering is the creation of a background story (narrative; Hawkins et al., 2013). A narrative can provide the justification for the actions required to gather quantitative data, which otherwise may have been more obtrusive. By reducing the obtrusiveness of the data gathering tools the participants can more easily concentrate on the task(s), which can also lead to an increase of the experience of flow (Pavlas, 2010).

1.1 Research question

This study proposes a hybrid model in which data, both qualitative and quantitative is gathered. This should result in an increase of the amount of accurate and unbiased data, while still including the in-depth interpretations that observations can provide (e.g. setting, physical activity, identifying issues, defining context). The expectation is that game elements can be instrumented to gather valid quantitative data and can eventually contribute to measuring the degree to which the educational goals have been accomplished. Game elements are already being instrumented to gather an incredible amount of data in entertainment games (e.g. response time, duration of events, gathered items, number of deaths), the addition of this type of data could increase the quality of emergency response exercises. With these data participants are presented with objectives data as input to their self-evaluation, as well reduce the dependence on external observers. Resulting in the research question of this study: "Can we use game elements to generate valid quantitative data regarding the accomplishment of the exercise's goals in order to support self-evaluation of participants?"

1.2 Research design

For our research we follow a design-based approach. Starting from existing disaster-exercises, specifically in the domain of rescue-operation we examined challenges in the traditional evaluation process. From these challenges we determined potential opportunities for improved data gathering in disaster exercises. In particular, we focus on the decision making process as this is a pivotal aspect of emergency response exercises. In contrast to the actual rescue operations such as extracting victims from collapsed buildings or applying medical care and treating injuries, the decision making process is less 'visible'. Decision making process, especially in the context of crisis management and disaster response are fuzzy (Van de Walle, Van den Eede & Murhen, 2009). This increases the difficulty for external observers to accurately reflect on the decisions made. While the outcome of the decisions and their impact on the overall rescue operations is observable and to a certain degree measurable, the process leading up to that decision is for example obscured through bi-lateral (informal) discussions, a wide variety of information sources and cognitive processes (van den Homberg, Meesters, & Van de Walle 2014).

Next we examined which specific learning objectives are commonly used in the disaster exercises when focusing on complex decisions making processes for crisis responders. Building on an existing serious game for disaster management, designed for non-professional responders, we have introduced non-intrusive game elements that supports the (automated) collection of data related to the learning objectives. The revised game has been played with several (non-professional) volunteers, demonstrating the feasibility of game elements to support data collection and the value of this data for the self-evaluation process by participants.

2. Exercise design

Multiple studies have illustrated the link between disaster exercises and games (Susi, Johannesson, & Backlund 2007, Di Loreto, Mora & Divitini, 2012). In both exercises and serious games generally two elements are important: planning and delivery (Gagné and Driscoll, 1975). Planning involves the preparation of activities and objectives, in serious games often referred to as the narrative. While delivery is the actual presentation or execution of these activities and the method or presentation to convey the learning objectives, which includes, especially in serious games, a certain amount of immersion. In the design stages, trainers first consider the particular (learning) objective of the exercise or game (planning). The resulting game or exercise can then be designed around this focus, incorporating the most efficient ways to deliver the learning experience (delivery), aiming to enact in a change in behavior.

The above outline gives various elements to consider in integrated data collection in the disaster exercise. First and foremost, the planning of the learning objectives: in our case the constructs that classify complex decision making processes. In the planning we also need consider the feedback and evaluation of the participants and their performance, specifically what data these various elements should provide in order to do meaningful self-evaluations. For the delivery these constructs need to be integrated in the exercise and placed in the narrative of the game. Moreover they need to be integrated in a way that maintains an immersive experience for the participants, but still yields valuable data for reflection. In the delivery we also need to consider the non-professional background of our participants for our initial field-test.

2.1 Learning goals

As mentioned the focus of this study is to gather quantitative data with regards to the components of complex decision-making in order to support self-evaluation by the participants. To experience complex decision-making in the emergency response context, literature review and interview reports with professionals indicated that there are five dimensions to consider. A person has to experience: (1) shared situational awareness (Harrald & Jefferson, 2007; Sapateiro & Antunes, 2009), (2) collaboration, (3) the use of a shared knowledge base (Comfort et al., 2004; Murphy & Jennex, 2006; Paas, Renkl & Sweller, 2004; Shim et al., 2002), (4) the ability to improvise (Hale & Moberg, 2005; Kendra & Wachtendorf, 2002; Mendonca, Beroggi & Wallace, 2001) and (5) be able to evaluate (Rae, 2004; Rudolph et al., 1998; Sapateiro & Antunes, 2009; Scholtens, Jorritsma & Helsloot, 2014).

2.2 Game elements

We implemented one game element for each dimension with which we intend to trigger an experience related to one of the five dimensions of complex decision-making. In addition, measurement features were also implemented to gather quantitative data. In total, four game elements that correspond to the five dimensions of complex decision-making were implemented in the exercise to measure to what degree participants had experienced the aforementioned elements. The dimension of shared situational awareness and shared knowledge base use, are represented within one game element. Both behaviors are meant to be triggered by the same game element.

- *Shared situational awareness:* An (1) information sharing website was created for the teams, where information concerning the emergency situation was uploaded by the coordination center. The teams received a mobile phone on which they could consult the website. The usage of the refresh button on the website was used to determine the priority of the participants in constructing awareness of global events. Thus, creating a potential indicator of shared situational awareness as defined in our study.

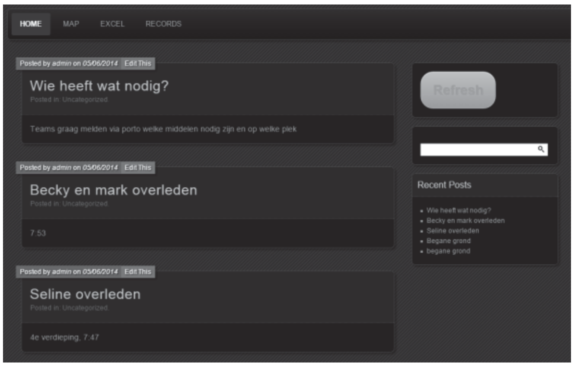

Figure 1: Information sharing website

- *Collaboration:* A (2) role-playing game feature was implemented to stimulate collaboration between participants. Teams consisting of three members (Team leader, Paramedic and Search and Rescue (SAR) worker), all with their own responsibilities, tasks and abilities. A 'victim application' was created for a tablet, which gave participants two opportunities to choose the correct treatment for a victim. When incorrect, participants were given the possibility to improvise on the treatment of a victim. To measure an aspect of collaboration, the time spent on collaboratively finding a solution for treating a victim was registered in the back-end of the application.

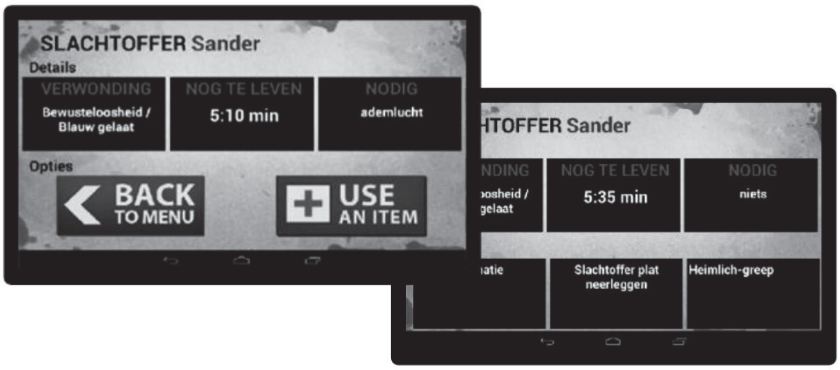

Figure 2: Victim application

- *Shared knowledge base:* for obtaining data about the (3) shared knowledge base use the information sharing website was also used. It registered how frequently participants used it, which is required to measure this construct within the exercise.
- *Improvise:* (4) In addition to measuring the time it takes to collaboratively find a treatment; we also register the participant's improvised entry solution for patient treatment.
- *Evaluate:* In the end, (5) participants evaluated regarding their experience by a Game experience questionnaire (GEQ). The GEQ measures if the participant experienced all five dimensions and therefore assessing the validity of the game elements and the data they gathered. The questionnaire consisted of 14 questions. These were related to the game elements that were implemented in the exercise: shared situational awareness (5 questions), collaboration (4 questions), shared knowledge base use (2 questions), improvisation (2 questions) and Evaluation (1 question). A 6 point Likert-scale was for each question.

2.3 Disaster in my backyard

Considering the *delivery* of the exercise, we recognized that the participants were not trained in emergency response, as such the organizers could not confront them with a real training exercise, which would include real dangers and expensive materials. To achieve a sense of immersion, gamification was used as a tool to create a simulated environment representing realistic encounters. Nicholson states that gamification is the use of game elements in non- game like contexts and considered to be a powerful tool for creating immersive and authentic experiences for educational purposes (Nicholson, 2012). Hands-on experience is required for learning in emergency response, in which gamification can provide a bridge between academic perspectives and real-world requirements.

Our exercise was based on an existing exercise called 'Disaster in my Backyard' (DIMB). DIMB was first introduced in 2012 at the ISCRAM Summer School to "give non-professional participants an immersive, first-time experience in crisis response and management, in order to improve the alignment of their preconceptions about crisis contexts with reality" (Meesters, 2014; Link, 2013). The original scenario entailed a wide range of crisis-encounters caused by a storm that hit the city of Ranst. Participants were divided in multiple Urban Search and Rescue teams. They had to collect information regarding the disaster area, retrieve and deliver supplies, stabilize victims, and evacuate victims. Participants experienced a series of events representative to a real-life emergency. To create a representative simulation of a real emergency exercise, 'Disaster in my Backyard' contained multiple game elements (e.g. co-operative play, levels, perks, difficulty adjustment, and technical systems) to build the aforementioned bridge and create an immersive experience.

2.4 Integration

Finally it is important to incorporate the described in the game elements in both a meaningful (i..e consistent with the narrative) and non-intrusive way. Therefore, in contrast to 'Disaster in my Backyard', 'Disaster at the UvA' takes an additional step by not only introducing game elements, but also building several back-end IT-systems. These systems were used to extract quantitative data from the game elements and assessed whether the game elements worked as intended (e.g. encouraged collaboration). These systems were linked or integrated with game elements presented to the participants such as the knowledge base, or the victim app.

3. Exercise

The exercise was conducted in the 'G' building at the University of Amsterdam. The building consisted of six floors which were all used during the exercise. Participants were divided in three different Urban Search and Rescue (USAR) teams (Blue, Green, and Red), there was one participant who functioned as the coordination center. Every USAR team was tasked with three main objectives: to (1) find victims, to (2) find items and to (3) stabilize victims, rescuing them.

For the first task the teams received a victim report that described 13 potential victims. Some victim locations were known and some locations were unknown. In addition, the victim report also often described the injury of the victims. Every team had to search the building for survivors and then had to attempt to save them before they died from their injuries. The victims' time to live corresponded to their injuries. As an example, a victim with internal bleeding had shorter to live than a victim with a broken ankle. The second task was to find items, such as a medical kit, sedative and respirator. Some victims required multiple items to save, which resulted in a total of 20 items which had to be gathered. The third task was to stabilize the victims, participants were asked to enter the victim's ID code in the app, use the item(s) and choose the right treatment. If they failed to answer correctly they were asked to improvise which would always be considered a correct answer, since the corresponding sub-goal of experiencing improvisation was already achieved. To clarify, the exercise's goal was to experience the five dimensions of complex decision-making in emergency response situations, not to be taught the right course of action.

3.1 Procedure

Participants were asked to attend a briefing, to take part in the exercise, and eventually evaluate. They were informed that photos were being made during the study for publishing purposes. The briefing informed participants of the goal of the exercise, what was expected from them, and how to use the technical tools. Each search and rescue worker was then handed a walkie-talkie for direct communication, the Team leader a smartphone to consult the information sharing website, and the Paramedic a tablet to stabilize victims. The teams were asked to save as many victims as possible within a 40-minute time frame.

Figure 3: Participants during 'Disaster at The UvA'

4. Results

Following the exercise participants were presented with a questionnaire consisting of two parts. The first questionnaire pertained to the exercise itself (the game experience questionnaire) designed to determine the level of game immersion. In particular, whether (1) the introduced game elements did indeed introduce the concepts of complex decisions making and (2) the intrusiveness of these game elements in the game experience. Following this first part, participants were presented with the data gathered through the game elements and asked to reflect on this data. In a group discussion, under the supervision of one of the observers, the participants reflected on their performance. The second part of the survey asked to participants to assess the value and reflect on this (first part of the) evaluation process.

4.1 Questionnaire results

The results of the questionnaires were analyzed to determine the mean on a 6-point scale and standard deviation for each sub-construct of the complex decision making elements.

- *Shared situational awareness*: The participants were asked to assess to what degree the game element 'information sharing website' (ISW) contributed to the experience of shared situational awareness (SSA). In general, participants experienced shared situational awareness (M=3.48, SD=.49)
- *Collaboration:* The participants were asked to assess to what degree the game element 'Role-playing' (RP) contributed to the collaboration experience. In general, participants experienced a strong form of collaboration within their team and between the differ search and rescue teams (M=4.56, SD=.99).
- *Shared knowledge base use:* The participants were asked to assess to what degree the game element 'information sharing website' (ISW) contributed to the experience of using a shared knowledge base (SKB). In general, participants experienced shared knowledge base use (M=3.88, SD=.39).
- *Improvisation:* The participants were asked to assess to what degree the game element 'victim app' contributed to the experience of improvising. In general, participants experienced improvisation element strongly in the exercise. (M=4.44, SD=1.07)
- *Evaluation:* The participants were asked to assess to what degree the 'Game experience questionnaire' (GEQ) contributed to the experience of 'self-evaluation'. In general, participants experienced self-evaluation (M=4.33, SD=1.41).

Table 1: Means and standard deviations for each individual question

Construct	Question	M	D
SSA	1. Awareness location of other teams by the ISW	1.75	0.71
	2. Team kept an eye on the ISW	4.5	0.93
	3. The information on the ISW was shared with the team	4.38	1.77
	4. The ISW presented us with scenario information	3.1	1.36
	5. The ISW is a functional database	3.63	1.19
COL	6. RP influenced the decision-making process	3.78	1.56
	7. RP encourages to start a dialogue	4.11	1.36
	8. Experience RP as beneficial to collaboration	4.89	1.36
	9. RP added an extra dimension to the exercise	5.44	0.73
SKB	10. Serious use of the ISW	3.75	1.67
	11. ISW considered as database for relevant information	4.00	1.31
IMP	12. Victim app encourages improvisation for treatment	3.88	1.81
	13. Serious use victim app	5.00	1.64
	14. Confronted with quantitative data from exercise	4.33	1.41

4.2 Quantitative data usable for exercise evaluation

An example of the data that we gathered from the victim application is shown in figure 5, which shows a screenshot made during the exercise. It shows that at that time, 9 victims out of 13 victims were saved. It shows that one team had already improvised on patient treatment. Separately, the information sharing website measured how frequently messages were (5) uploaded and consulted by the teams. Below, we present an example of the data of the three teams.

Table 2: Back-end example of the information sharing website

Username	Page views
Green	41
Red	33
Blue	14

5. Discussion

The possibility of gathering quantitative data via game elements was supported by our current findings. Although, this data in its current state can only be used as descriptive data. Additional analysis tools are required to be able to draw conclusions from this data. The technical systems stored all data of the exercise into the back-end as intended, which was easy to access and export. Although it will be the focus of future research, preliminary results showed promise with basic pattern seeking.

Furthermore, tools need to be developed for quick analyses that are easy to use for the observers. After implementation, these tools can be utilized in exercises similar to this study to assess the functionality and usability of measuring educational goals by means of the hybrid model, consisting of observers gathering qualitative data and game elements gathering quantitative data. On a larger scale, we postulate that the quantitative data, gathered from different exercises, can be analyzed and evaluated for purposes which extend the learning goals of one scenario (e.g. changing training policy, adjusting the learning curve, compare results).

In particular, the game experience-questionnaire played an important role. During the questionnaire participants were presented with data collected from the other game elements and asked to reflect on it. The questionnaire during our exercise served therefore a dual purpose: (1) examine the viability of the various game elements to collect meaningful data for the participants and (2) encourage the participants to examine and reflect on the provided data by providing them with a structure to do so. In this way the questionnaire not only helped to validate the research and the resulting implementation through game elements, but is in itself an important part of the self-evaluation process, specially by providing guidelines for both observers and participants to reflect on and give meaning to collected data.

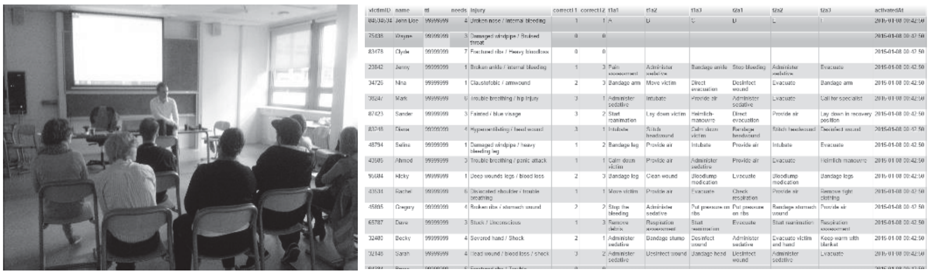

Figure 4: Evaluation session support by data gathered through game elements

6. Conclusion

Data gathering regarding learning goals by gamification, it seems to have found its way into the area of emergency response. Our questionnaire results generally indicated that the game elements implemented to measure components of the five dimensions of complex decision-making were supported. The game elements measured the intended variables and showed that it gathered quantitative data relevant to the corresponding dimension. Additionally, we have shown that technical systems and valid game elements can assist evaluators with gathering accurate and unbiased data, solving the problems of cognitive limitations and type of data. Moreover, by integrating the data collection through game-elements that seamlessly integrate with the exercise, the data-collection process does not disrupt the immersion of the participants in the exercise. Collecting data through these elements observers avoids disrupting the exercise flow and introducing a bias.

While the collected quantitative data collected in itself has limited value, considering that every participant has a different level of experience, background or expertise, and every exercise-instance has a different scenario, difficulty and circumstances. This makes the collected not suitable for a summative in which the focus is more on whether or not certain (pre-determined) objectives have been achieved (Scriven, 1991). However, the field-test did illustrate the potential to support a formative approach to assesses the participants' performance, reflecting on the various elements of complex decision making enabling them to improve over time. In short, data-gathering through the introduction of gamification elements will not replace observers but will support them by enabling more comprehensive assessment through providing data for self-evaluation by participants.

In general, the introduction of data gathering through gamification, leveraging the benefits of non-intrusive data-collection are a potentially valuable addition to the feedback and evaluation process for disaster exercises. While the scope of this research is limited with its focus on complex-decision making and non-professional participants, it does demonstrate the potential and feasibility of game elements to support data collection for self-evaluation. Most importantly it demonstrates the approach and consideration to design and include such gamification elements.

Acknowledgements

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BrainPlay: Serious Game, Serious Learning?

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Abstract: Games are increasingly being used in educational contexts. The view of some game educationists is that games are able to effectively fulfil the requirements of a constructivist learning pedagogy. It is suggested, for example, that games are useful at representing complexity and often possess mechanisms that make learning more effective through mimicking behaviours required for study. This includes such elements as a call to focus, increasing levels of difficulty of skill, repetition and the need for players to regularly remember elements such as rules or previous moves. But while there has been much recent progress in this area, one aspect of learning that has not been adequately incorporated into game pedagogy is metacognition or the ability to reflect on one's own thinking process. Thus, whilst many games are effective at teaching specific subjects, facts or skill, and some games support metacognitive processes, no games to date appear to focus on the ability for students to understand the inter-relationship of neuroscience and the behavioural techniques of how humans learn. This paper will outline my research plan to support the creation of a game to teach this inter-relationship. In this paper I will report on the theoretical background to game-based learning, considerations of how to conduct the game design and outline a methodological approach to test the capacity of the game. BrainPlay is a PhD by artefact and dissertation. The artefact is the Board Game designed to teach primary school students from 10 – 12 years old current neuroscientific models and practices of learning or how the human brain acquires, retains and processes facts and knowledge (explicit memory) effectively. The dissertation examines the results from testing the artefact on 3 populations of students to determine whether by playing the game within a class-room setting over a 10 week period the students alter the way they behave in class-room study as observed by their teachers or if they increase their academic scores over time.

Keywords: game-based learning, neuroscience, how to learn, primary school

1. Introduction

In the past 15 years there have been a number of calls to use digital games as educational tools (Prensky 2001; Gee 2005; Schaffer & Gee 2006) and these have been answered with an increase in the production of games that claim to be designed for educational purposes (Greer 2014) and a reported growth in the adoption of games within classrooms (Malykhina 2014). Some constructivist educators (Papert & Caperton 1999; Salen 2008) believe that with the advent of the internet and the mass usage of information technology, the learning needs of students have changed from an ability to regurgitate facts and figures to being able to locate, assess, evaluate and put-together information in an effective manner. They suggest that games can provide this process as the mechanisms of the game format allows for the provision of complex environments that more accurately mimic the natural world (Rosario & Widmeyer 2009) and the interactivity of a game can stimulate cognitive processes required for learning (Nouchi et al. 2013).

How humans learn is complex and successful learning is multifaceted biologically, behaviourally and contextually. To learn how-humans-learn is the ability to recognise multiple systems with potentially complex interrelated problems and work out methods to solve them. Games are useful at representing complexity and often possess mechanics that make learning a cognitive element of the play such as a call to focus, increasing levels of difficulty or skill – scaffolding, repetition and the need to regularly recall elements such as rules or previous moves. Whilst many games teach specific subjects, facts or skills, no games, to the knowledge of the researcher, teach the neuroscience or behavioural techniques of 'how humans learn'. This research examines this explicit problem of learning how-to-learn and by teaching children how-to-learn, using a game within a class-room setting, asks:

- Can playing this game (artefact) improve academic performance in schools?
- Can playing this game (artefact) enhance students' cognitive skills and learning behaviours?
- Can the process of designing the game (artefact) identify heuristic methods for the application of principles to game-design?

In this paper I will describe the theoretical background to game-based learning and outline the relevance of the growth of games within educational settings to suggest that a game that teaches the metacognition of learning may improve student academic outcomes. I will describe the process that I will adopt to develop such a game and the methodology that I will use to test the capacity of this game to answer my research questions.

I conclude with a brief statement on the expectations of my findings and impediments to the study.

2. Theoretical background

Games, play and learning share a relationship that has been explored by Huizinga, Callois and Piaget since the late 1930's. Huizinga argues that as a behaviour exhibited by both humans and animals, play is a 'primary category of life' and that it is a 'significant form' of activity with a social function that is embedded, historically and psychologically in human culture (Huizinga 1950). For Huizinga, games and their many forms are one of the cultural manifestations of this essential play element. The French philosopher Roger Callois (1961), in agreement with Huizinga, expanded on this thinking by both classifying play and games and analysing what the essence of a game is. He proposed a framework of four elements of play, that remain largely unchallenged today, namely Agon (competition), Alea (chance), Mimicry (imagination) and Ilinx (physical sensation) that exist within a continuum of behaviour between Paidia or free play e.g. the way children might gambol about with no reason and Ludus or a specific defined set of enforceable rules e.g. the way individuals might play a game of chess. This examination of play is both historically and philosophically situated with the work of Jean Piaget (1962)and his efforts to understand the meaning of play behaviour in children. Where Huizinga and Callois sought to identify and classify play and games, Piaget sought to examine the how and why of play in relation to the physical and psychological development of the child. This research contributed, in part, to the theory of Constructivism which suggests humans learn by building upon their previous experience, which has generated the expression – learning by doing. Psychologist Lev Vygostky also believed that experience develops the individual and proposed, amongst a number of learning theories, the Zone of Proximal Development (ZPG) (1978) also known as "the Goldilocks principle". ZPG refers to the idea that learning occurs when the challenge is not too hard and not too easy, but just right. Vygotsky's Constructivist thinking also correlates with the more recent theory of Flow (Csikszentmihalyi 1975) that describes the prime emotional state of engagement that is reached when an individual is fully and happily immersed in an activity to the extent that other thoughts or activities are completely outside their focus. This pleasurable state, is reached when the individual's emotional state resides between and yet beyond "boredom and anxiety". As Csikszentmihalyi describes it "what is usually lost in Flow is not the awareness of one's body or of one's functions, but only the self-construct, the intermediacy which one leaves to interpose between stimulus and response." This theory relates to the emotional state that people experience when playing a (video) game (Sherry 2004) and another reason why games are increasingly seen by practitioners as useful education tools (Annetta 2010). Metacognition is the ability to reflect on our own thinking and was promoted as an area of research by John Flavell when he examined the development of children's cognition and memory (1979). He found that our ability to consider our own cognitive processes grew throughout childhood and adolescence. Schraw and Moshman have since proposed a 'framework' of metacognition that includes an understanding of cognitive science, the ability to alter behaviour within a given situation or self-regulation and the coordination of these structures by the individual (Schraw & Moshman 1995). These Metacognitive theories as they describe them have become more relevant within the field of education and learning as much research has suggested that these forms of metacognition along with metacognitive strategies produce better academic results (Mega et al. 2013; Çalişkan & Sünbül 2011; Laidra et al. 2007; Sperling et al. 2012).

Educational practices that promote these theories have become known as Constructivist Learning Environments or CLEs. Jonassen (1999) proposed that there are seven characteristics that typify CLEs, namely that they;

- Provide multiple representations of reality: (as) multiple representations avoid oversimplification and represent the complexity of the real world.
- Emphasize knowledge construction instead of knowledge reproduction.
- Emphasize authentic tasks in a meaningful context rather than abstract instruction out of context.
- Provide learning environments such as real-world settings or case-based learning instead of predetermined sequences of instruction.
- Encourage thoughtful reflection on experience.
- Enable context- and content- dependent knowledge construction.
- Support collaborative construction of knowledge through social negotiation, not competition among learners for recognition.In summary, Constructivist Learning Environments (CLEs) are theoretically tested methods of learning and games would appear to make good CLEs as they are able to closely match Jonassen's set of characteristics. This study theorises that by teaching children how they learn, through an

effective learning mechanism such as a constructivist learning tool i.e. a game, they will improve their ability to learn in both the short and long term.

3. The growth of the use of games in education

Marc Prensky is considered a foundation thinker of Game-based learning from his book of 2001 *Digital Game-Based Learning* where he proposed that digital games will eventually be used ubiquitously for educational purposes as the medium is fun and therefore motivating for students to use. He also proposed that this focus would change students from thinking of themselves as learners and more as players, the experience inviting repeat play, thereby rapidly improving skills or knowledge and opportunities for reflective thinking.

Despite the foundations of the term 'game-based learning' originating within a digital context, the establishment of the game-form as a constructivist learning environment suggests that both digital and analogue games are compatible for game-based learning as implied by Baker, Navarro and Hoek (cited in (Connolly, Stansfield, & Boyle 2009). Hundreds of games have been historically and are now being specifically designed for learning subjects eg maths and science or skills such as strategy and debating or cognitive abilities such as working memory. Two middle schools (starting from Grade 6) based in the United States of America have been set up specifically to explore Game-based learning at a systemic level. These are *Quest to Learn* based in New York City and *Playmaker School* based in Los Angeles. They are all part of what is termed the *Serious Games* movement of the last 12 years. Where *Serious Games* are games that are designed primarily for purposes such as training, health, education and public policy and that players of the games in addition to having an enjoyable or entertaining experience, learn, create or think differently after playing the game. The movement was strongly championed by Jane McGonigal in her book *Reality is Broken* (2011) but is argued to have had its oxymoronic title, at least, in Ben Sawyer's 2002 white paper entitled *Serious Games: Improving Public Policy through Game-based Learning and Simulation* (Djaouti & Alvarez 2011).

This interest in game-based learning has persisted as more and more studies have suggested that game-based learning has better academic outcomes than traditional learning (Clark et al. 2014; Vogel et al. 2006; Wouters et al. 2013) and the potential for games designed for other, desirable 21st Century, learning outcomes such as collaboration and cognitive strategies is explored. Within this same time frame, a number of other psychological and behavioural techniques have also been found to improve academic outcomes. These include when students believe or are taught a *Growth Mindset* or that learning is dependent upon their own effort and not on a fixed intellectual capacity (Blackwell et al. 2007; Romero et al. 2014). Additionally, practical study techniques such as students quizzing themselves on a topic rather than re-reading; spacing studying over time; mixing up different types of topic materials within a single session; generating explanations of 'why is it so?' and reflecting on how that information is related to already known information have also shown efficacy in improving academic outcomes. (Dunlosky et al. 2013). This last ability, to reflect upon your own thinking, is Metacognition and metacognitive strategies are ranked 13th out of 138 domains that have an effect on student's academic success according to Hattie (2008)**.**

With a growing understanding of positive psychology and other behaviours that make learning more successful including exercise, play, autonomy (Deci 2002), social interaction (Caprara et al. 2000), emotional stability (Panksepp 2011) and sleep (Groch et al. 2013); the problem would seem to be how to effectively teach students how-to-learn. In addition to educational techniques, our understanding of the neuroscience of human learning is growing rapidly with knowledge that the brain continuously grows new cells (neurogenesis) (Gould 1999; Gage 2000), has the ability to create new connections (neuroplasticity), that new cells survive longer when we learn and that learning is difficult (Curlik & Shors 2011) and that encoding and recalling memories, physically changes neurons and their electrical and chemical relationship and storage within the brain neocortex (Bear, Mark F. Connors, Barry W. Paradiso 2007). Additionally, Working Memory, or the ability to hold and manipulate a number of pieces of information in mind (Gathercole et al. 2004) is becoming established as a further predictor of academic ability (Dumontheil & Klingberg 2012; Unsworth et al. 2015)

Games appear to both fit Jonassen's criteria as a 'natural' Constructivist Learning Environment and hold the potential, as a format, to include many of these physical and psychological elements that have been shown to aid academic success. Though, some scholars argue that games "are limited in their design in satisfying all the criteria for a constructivist learning environment". They point to the inability of games to, eventually, remove all scaffolds and allow children to complete tasks independently and (provide) opportunities for peer interactions (Obikwelu & Read 2012) Further, Designers for classroom based games might consider whether these games are successful as agents of engagement if individuals are not making a completely free choice to play them. Thus, where school curriculum content is delivered through game-play and children have no volition in choosing to play that game, the benefits of using a game method to teach a topic could be reduced.

These criticisms will be tested in the making of the game (artefact) for this project as it explores the balance of design within the game-play between Callois' free play Paidia and rule based Ludus approach and also will make observations of whether game volition changes within a classroom environment.

4. Game design

Nous is the strategy board game that I'm designing to test the question of whether teaching the neuroscience of learning and metacognitive strategies will be able to improve primary school academic outcomes.

The game aims to incorporate evidence based game-play mechanisms in the design that have proven successful in measures such as playfulness; engagement; attention; academic acquisition and retention; and assessment such as the introducing surprising events (van der Spek et al. 2013) There are a number of design methods available to the designer to support these aims. Two such approaches that will be utilised within this research are known as MDA and Schell's Lenses. MDA is a game design framework developed during workshops at the Game Developers Conference in the USA between 2001 and 2004 (Hunicke et al. 2004) This framework considers both the game designer and the game player within the design process and breaks down games into the elements of "Rules, System and Fun" equating them to design components of "Mechanics, Dynamics and Aesthetics" or MDA. At the heart of this design thinking is that it is the playing of the game or the human play behaviours that are an essential creative component of the game. Another tool to be used in the development of the game artefact are highly pragmatic design "lenses" (Schell 2008) that ask the designer a set of questions to assist them in determining the goals of the game from both the designer's and players' perspectives, for example; "The Physical Interface" or "What does the Player pick up and touch?" or " "Curiosity" and "What questions does my game put into the players mind?"

Within the design, educational considerations re metacognition will be established by reviewing effective metacognitive strategies to determine whether they can be creatively translated within the game design.

5. Research methods

The research method is testing the capacity of the game artefact, through play, to 1. effectively impart knowledge and understanding to students of the neuroscience and behaviours of how humans learn and 2. determine whether this knowledge and understanding leads to increases in student academic performance.

The research is a mixed method plan that includes: the design and creation of a Board Game (Artefact) for children in their 5th and 6th year of class-room based schooling (approx. ages 10 -12 years old); a quantitative comparative analysis of the games' educational effectiveness via retention of the subject matter, and later, a test on academic outcomes. A qualitative analysis of educators' impressions of students' behaviour/s before, during and after playing the game within the class-room will also be conducted to assess any perceived changes in metacognitive behaviours.

The game will be tested on 2 populations (n=100) of students within a classroom setting over a 10 week period to first, determine whether the students increase their knowledge of the game's learning content (i.e. the neurobiology and behaviours of learning) and secondly, whether their class-room behaviour is altered as observed by their teachers. Researcher observations of these groups will inform design iterations of the game prior to a 3rd population of students (n=50) play-testing the game with a pre and post-test assessment. A standardised academic achievement test will be administered to students before the game-play (T= 1), after 10 weeks of play (T=2), and after 12 weeks of no-further play (T=3). The standardised testing will be used to assess if the game-based-learning translates to any variation in academic scores.

5.1 Design and development

The Board games will be designed and developed to an early prototype standard for class-room testing in Term 3, 2015.

5.2 Recruitment

Three Victorian Primary Schools will be invited to participate via approach by the researcher to the School Principal. Meetings with the Principal and relevant teachers will be conducted to establish the project outline and discuss issues and protocols.

5.3 Pre-play

The project and the game will be introduced by the researcher to each participating class group to demonstrate the rules and gameplay and inform the students that they will be filmed and recorded during play.

The final game iteration will be tested on a single class experimental group and single class control group. Students in this experimental play and control group will be administered purchased Australian Council for Education Research (ACER) standardised "Progressive Achievement Tests (PAT)" in Science and Reading as a comparative benchmark to identify if the intervention of teaching students effective learning techniques, improves their ability to learn across subject disciplines. The ACER PAT Science and Reading tests are well recognised academic achievement tests that are targeted at specific school grade levels. A statistical analysis of variance (ANOVA) for academic ability will be conducted between these groups prior to playing at Time 1 (T1), after 10 weeks of playing Time 2 (T2), and after a further 10 weeks of no-play at Time 3 (T3).

5.4 Gameplay

Up to 6 students will play the game without teacher support for 45 minutes for a minimum of once per week over 10 weeks, rotating play within a classroom to enable all students a chance to have play time. The researcher will at these times be available to provide clarification of terms or rules to assist game play and note these interactions in order to improve the instruction or design affordance for future play.

5.5 Post-play

For all participating students, a multiple choice online quiz will be given to ascertain how much of the game's learning content has been retained and can be recalled at the end of each testing term. Classroom Teachers and other specialist teachers that interact with the intervention students will be interviewed at the end of each testing term to record their observations of student behaviour and identify any observable behavioural impacts of the game-play. Only the final experimental play and control groups will be re-administered the purchased ACER standardised "Progressive Achievement Tests (PAT)" in Science and Reading as a comparative benchmark to identify if the intervention of teaching students effective learning techniques, improves their ability to learn across subject disciplines.

5.6 Analysis

Results from the online quiz about the game's learning content will be used to refine both instructional and interaction elements in the game design. Teacher observations will be reviewed and analysed for any consistent themes or behavioural outcomes. The pre and post test ANOVA will compare academic achievement over time to investigate if there is any overall transferring benefit to playing the game. Existing Data collected from the sample population of students needs to assume statistical variance and thus key data fields that could be correlated with the larger population will include, age, gender, Socio Economic Status (SES) in addition to benchmark academic scores and academic scores post the interventions. As SES has been shown to have a causal effect on academic outcome (Sirin 2005; Steinmayr et al. 2012), it is collected in this study to offset statistical variance within the population.

6. Expectations and impediments to the study

Relative to the control class group, this study anticipates that students playing the game artefact *Nous* will: learn knowledge about the human brain and how humans learn; develop an understanding that learning requires effort; improve their learning behaviours such as co-operative discussion within the classroom and improve their academic scores on the given standardised tests over time. Impediments to the study include the accessibility of time within a school curriculum and engagement of class group teachers within the study. There are also a number of assumptions that are being made for this study that may prove problematic in gathering data, namely that students are motivated by fun and play and therefore directing play by enforcing regular play of the game will mitigate their autonomy which is considered a strong theory for motivation (Deci 2002) . Hopefully some of these impediments may be mitigated by reducing the class teachers need to learn any new material by ensuring the subject material is completely contained within the game framework, requiring no knowledge of the subject matter by the teacher and by being introduced to the class as more of a play activity/elective that is completely self-organised without any need for instruction. Game development and timing is also a potential problem as the game development needs to maintain schedule to fit within the academic year.

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Training Emotionally Intelligent Leaders: The Case of Massively Multiplayer Online Games

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Abstract: Over the last decades, digital games have evolved to complex, social environments like Massively Multiplayer Online Games (MMOGs) which are a practice arena for 21st century skills, such as leadership. This paper outlines the conceptual framework behind a doctoral project currently in progress, which examines emotional intelligence (EI) as a leadership skill that can be developed in MMOGs. The main statement of this PhD is that the skills learned in the game settings can help people to become more emotionally intelligent in real life and workplace. The hypotheses of this study that leaders in MMOGs with high emotional intelligence can become transformational leaders, inspiring team members and enhancing team cohesion which can lead to team effectiveness. In order to address this issue, a preliminary study using qualitative and quantitative data from interviews and a survey, will examine the elements of perceived emotional intelligence, transformational leadership, team cohesion and team viability acquired by MMOGs players and their perceived transfer of these skills in their workplace settings. The conceptual framework of this study is based on the Input-Process-Output (IPO) team effectiveness model, which is used widely in organizational researches. Moreover, players' perceptions of the game elements that foster emotional intelligence will also be identified during the preliminary study. These findings will contribute to the final stage of this project, including the design principles for the development of an emotional intelligence training course with real, on-the-job content to teach leadership using essential gamification elements.

Keywords: MMOGs, emotional intelligence, leadership, team cohesion, team effectiveness, team viability

1. Introduction

Massively Multiplayer Online Games (MMOGs) attract millions of players on a daily basis and recent studies claim that they are a practice arena for 21st century skills (Galarneau & Zibit, 2007) such as leadership. In this type of games, advancement involves collaboration among groups of users in order to achieve a challenge. Thus, in groups, leaders deal with strategy issues, providing opportunities for short-term and long-term leadership experiences (Yee, 2006). These kind of qualities of gifted gaming leaders seem to be similar to those needed in a corporate setting (IBM, 2006; 2007).

It seems that the emergence of virtual environments and games has changed the ways that business may be conducted (Fetscherin, 2008), while the relationship between gaming and real life is thought to be both socially and economically significant (Castronova, 2005; Taylor, 2006). However, despite the growing interest of the scientific community in MMOGs, empirical research on the development of leadership skills and especially on emotional intelligence in these games is limited (De Freitas, 2012). By exploring what makes a good leader in a MMOG may further our understanding of leadership phenomena in real life settings (Goh & Wasko, 2009).

On the other hand, studies highlight as important leadership skills the ability for conflict resolution, discipline, motivation, coordination, nurturing and emotional support, delegation, training, retention, recruitment, scheduling, and politicking (Castronova, 2005; IBM, 2006; IBM, 2007; Reeves et al., 2007), while there is a general growing interest on the enhancement of soft skills in the workplace. Emotional intelligence (EI) is thought to be an important skill for success, as the ability to understand and manage emotions is an important factor in performance both on individual level and group level, including elements of self-awareness, self-management, social awareness, and relationship management (Goleman, Boyatzis, & McKee, 2002).

The importance of emotional intelligence in leadership has led the organizations to increasingly search for engaging training programs for their employees that can help them become more emotionally intelligent and enhance their performance. Thus, an increasingly number of consultants sell workshops and seminars designed to help people become more emotionally competent and socially skilled (Cherniss et al., 1998).

However, though many businesses spent a significant amount of time and money on emotional intelligence and leadership training programs, after training is completed, only a small percent of the skills taught are applied on the job (Kivland & King, 2015). This failure of transfer of skills has been linked with unattractive teaching techniques, such as lectures and presentations, leading to participants' lack of engagement and motivation toward the training program. In addition, the format of the training usually doesn't provide trainees with opportunities to practice what they have learned or the intrinsic or extrinsic motivation to engage with the program. Moreover, there seems to be a lack of connection between leadership development and its application to actual situations.

In MMOGs a successful leader has to build credibility by first creating strong personal relationships with their followers, revealing the most important skills in these games; the ability to communicate, organize and activate guild members (IBM, 2006; 2007). However, this is very close to the actions of both a transformational leader and of an emotional intelligent leader.

This paper outlines the conceptual framework behind a doctoral project currently in progress, which examines emotional intelligence as a leadership skill that can be developed in MMOGs. The main hypothesis of the study is that in these games, leaders acting with emotional intelligence can apply transformational leadership to their team members, which can enhance team cohesion and advance team performance. Moreover, it is argued that the skills learned in the game settings can help people to become more emotionally intelligent in real life and workplace. This transfer of skills could result to more efficient leaders with high emotional intelligence. The results of the study will contribute to the limited empirical research on MMOGs and to the design and assessment of an emotional intelligence training course with gamification elements.

Understanding the social practices and constructivist ecologies being created by these interactions in massively multiplayer games will provide a glimpse into new kinds of innovation ecologies (Brown, 2004). Furthermore, by leveraging the lessons from online gaming environments, companies can gain a better understanding of the ways in which the next generation of leaders will need to operate in the future (IBM, 2006; 2007; Reeves et al., 2007).

2. Emotional intelligence

Emotional Intelligence (EI) involves "the ability to perceive accurately, appraise, and express emotion; the ability to access and/or generate feelings when they facilitate thought; the ability to understand emotion and emotional knowledge; and the ability to regulate emotions to promote emotional and intellectual growth" (Mayer and Salovey, 1997, p. 10). It is defined by different theoretical models, such as the Salovey-Mayer model (1997), the Goleman model (1998) and the Bar-On model (1997) and it is thought to matter twice as much as IQ (Goleman, 1998).

Moreover, researches suggest that EI is the basis for the development of competencies important in every job (Cherniss, 2000) and most importantly, it is reflected in effective leadership and may account for how effective leaders monitor and respond to subordinates and make them feel at work (Palmer et al., 2001). Other studies revealed that elements of emotional intelligence and specific behaviors are associated with leadership effectiveness and ineffectiveness (Ruderman et. al, 2001). Emotional intelligence is an increasingly popular tool for developing effective leadership skills, but despite this popularity, there is little empirical research that substantiates the efficacy of emotional intelligence in these areas (Palmer et al., 2001).

With emotional intelligence having been associated with leadership, Goleman (1998; 2004) suggested that the main components of Emotional Intelligence at work are:

- Self-Awareness, which includes the ability to recognize and understand personal moods and emotions and drives, as well as their effect on others and a self-aware person is one practiced in making the necessary honest assessments of an organization as well as of him/her.
- Self-Regulation, referring to the ability to control or redirect disruptive impulses and moods and a self-regulated person usually thinks before acting.
- Motivation, including a person's own drive and the passion to work for reasons that go beyond money or status having the propensity to pursue goals with energy and persistence. This intrinsic motivation is linked with high levels of organizational loyalty and is a typical of great leaders (Hopper, 2005).
- Empathy which is one's ability to understand the emotional makeup of other people and helps leaders to heighten collaboration more accurately "read" the intentions of clients, and "retain talent," leading to increased job satisfaction and decreased turnover.

- Social Skills, which are typically associated with effective leadership, since proficiency in managing relationships and building networks is considered a key leadership capability in most companies (Goleman, 2004).

These components play a key role in determining success, both in personal life and in the workplace.

3. Transformational leadership and emotional intelligence

Based on the difficulty in differentiation between management and leadership Bass (1985) claimed that the differences are in characteristics and behaviors and established two concepts: "transforming leadership" and "transactional leadership".

Transformational Leadership (TL) is a process by which change or transformation is introduced to individuals and/or organizations (Kent, Crotts & Aziz, 2001) and it is described as “that activity which stimulates purposeful activity in others by changing the way they look at the world around them and relate to one another. It affects people’s personal beliefs by touching their hearts and minds” (Nicholls, 1994, p. 11). There are four components of Transformational Leadership: *Idealized Influence, Inspirational Motivation, Intellectual Stimulation and Individualized Consideration* (Bass, 1985).

Transforming leaders work towards the benefit of the team, organization and/or community and have additional influence on their followers, by broadening and elevating their goals and providing them with the confidence to perform beyond the expectations specified in the implicit or explicit exchange agreement (Dvir, Dov, Avolio & Shami, 2002). They promote a heightened awareness of important organizational issues while increasing the confidence of followers (Bass, 1990).

It is often viewed as a type of distributive leadership since it encompasses a shared vision and commitment to change (Hallinger, 2003). More specifically, Palmer et al. (2001) suggested that EI may be an underlying competency of TL, and that it can identify potentially effective leaders and as a tool for nurturing effective leadership skills.

It has been stated that followers perceive leaders with high EI as more effective and transformational and that EI is linked to TL behaviors (Sivanathan & Fekken, 2002). Moreover, Gardner and Stough (2002) claimed that leaders with high EI can understand emotions and are able to perceive more accurately the extent to which followers’ expectations can be raised. Leaders with high emotional intelligence are thought to be better at mood management (Ciarrochi et al., 2000) and can promote creativity in followers (Zhou and George, 2003). Barling et al. (2000) stated that individuals high in EI use transformational behaviors. In addition, EI in leaders seems to encourage conscientiousness and altruism in followers (Singh & Modassir, 2008). With EI being a critical factor for TL behavior we can hypothesize that Transformational leadership and emotional intelligence are positively related.

However, we know very little about how leaders create and manage work groups (Zaccaro, Rittman, & Marks, 2001). Thus, research needs consider leadership as a set of functions that need to be fulfilled and satisfied in teams (Day et al., 2004) and shift toward an exploration of the complexity inherent to distributed leadership (Rico et al., 2011).

4. MMOGs: Practicing leadership skills in a community - based environment

MMOGs and MMORPGs, are not simply games in the traditional rules-based sense, but rather loosely structured complex learning systems with a full range of social and material practices (Steinkuehler, 2004). In these games, players are self-organized into groups/teams, initially quite often chaotic and disorganized that over a period of time and spontaneously, players learn to sync their behaviors to the behaviors of other players (Galarneau & Zibit, 2007). The numerous groups of players, including individuals from around the world, “emerge in an entirely decentralised and self-organised way, engaging in group pursuits and assisting each other to learn how the game world functions, or even co-producing the game world in a negotiated dance with developers. This group emergence follows the classic rules of emergence in biological systems” (Galarneau, 2005). The social structure of MMOGs offers opportunities for shared experience, collaboration, reward and reputation in the group members. In these complex systems the players have to fulfill increasingly complex tasks, often requiring precise coordinated effort and high levels of communication and collaboration, increased with the complexity of the tasks at hand (Siitonen, 2009). Thus, as Siitonen (2009) states “it is not surprising that leadership, both formal and emergent, is an integral element of the social organization of many player organizations”.

During the last years, a number of researches studied the identification of employees with leadership skills in virtual worlds and explored the characteristics of leadership in popular MMOGs (IBM, 2006, 2007; DeMarco et al., 2007, Kahai, Carroll, & Jestice, 2007). According to these studies, leadership behaviors appear to be relevant in both gaming and corporate environments (IBM, 2006; 2007), and that MMORPG leadership approaches can be used to improve leadership effectiveness within the enterprise (Reeves et al., 2007).

In these games, the best leaders build credibility by first creating strong personal relationships with their followers, revealing the most important skills in these games; the ability to communicate, organize and activate guild members (IBM, 2006; 2007). On this basis, there is a need for researching the social structures formed in these multiplayer games through their interactions with their players. Important issues concerning MMOGs are associated with the sense of community developed in these games, the group structure, the endogenous and exogenous factors that stimulate their users, the collaboration between users, and cognitive skills such as decision making, problem solving, and develop leadership characteristics (Sidorko, 2009; Papargyris & Poulymenakou, 2009; Wyld, 2010; Konetes 2010).

Moreover, players are usually truly committed to their team and keep returning to play the game for a long period of time. Sellers (2002) suggested that the social bonds created by players motivate them and keep them returning to a game based on their need to form communities. In these social groups, they seem to develop a psychological group cohesion that is sometimes so strong that some participants reported staying in the game for the sake of the group, rather than individual motivations (Taylor & Taylor, 2009).

In general, group cohesion has been linked to group performance (Chang et al, 2006). In MMOGs, the ability to create groups and develop a sense of community in a game has been found to be motivating for the players (Mysirlaki & Paraskeva, 2011). Moreover, the sense of belonging in a community was positive correlated with the game, implying that the performance of a player can be enhanced when the sense of community in a game is strong. These findings suggest that the development of groups of players in a game is possible to increase intrinsic motivation of players and enhance their performance in the game. However, the social organization and the dynamics of group structure and role –playing in MMOGs have been studied in previous studies (Koster, 2005; Reeves et al., 2005), stressing the importance of the community in these games and focusing on issues of leadership and leadership communication, which can have drastic effects on the operation and social cohesion of online groups. The main question is the actual role of the leader in these teams and if a leader's emotional intelligence can conclude to transformational leadership and influence team’s cohesion and effectiveness.

Hackman (1987) was the first who attempted to explain effectiveness by making a distinction between performance outcomes (performance quality, speed of solution, number of errors) and other outcomes (member satisfaction, cohesiveness, attitude change, sociometric structure). In general, the outcomes achieved by the team are usually considered as the performance of a team, its outcomes (Beal, Cohen, Burke, & McLendon, 2003) and team viability (Balkundi & Harrison, 2006). In MMOGs, successful groups tend to work well together for a long time, revealing a possible strong team viability, defined as the team members' assessments of their ability to work together as a unit in the future (Barrick et al., 1998; Hackman, 1987; Kozlowski & Bell, 2003).

Working groups with higher average levels of emotional stability have a higher viability, and the social cohesion of a group seems to be related to its viability (Barrick et al., 1998). This is attributed to the fact that cohesion is an indication of positive interpersonal dynamics within the group. In this study the cohesion between team players in MMOGs is expected to be associated with the viability of the team, and therefore, its effectiveness.

5. Research methodology

The aim of this PhD project is to explore the role of emotional intelligence as a driver of effectiveness for virtual teams within MMOGs. More specifically, it will examine the extent to which leader’s emotional intelligence is a crucial individual input for performing a transformational leadership behavior and can result to team’s cohesion, which in turn can enhance team’s viability; as an indicator of effectiveness.

During the literature review process, possible relationships between team-leader emotional intelligence, transformational leadership behavior, team cohesion and team viability were revealed; forming the hypotheses of this study:

H1: Team-members' perception of team-leader emotional intelligence will be positively related to transformational leadership.

H2: Team-members' perception of team-leader transformational leadership behavior will be positively related to team cohesion.

H3: Team members' perception of team-leader emotional intelligence will be positively related to team cohesion.

H4: Team cohesion is positively related to team viability.

For the purposes of this PhD project, the Input-Processes-Output model will be used to analyze MMOGs not as just games, but as complex systems that have characteristics that can be useful for other domains, such as enterprise and training settings, by exploring players' leadership skills and their effect on their team. Numerous researches on the effectiveness of teams have been based on the Input-Processes-Output (IPO) model (McGrath, 1964) which identifies the composition, structure and processes of teams and the key antecedents to their effectiveness. The conceptual framework of this PhD study focuses on three main areas, as the have been highlighted by the hypotheses: Team Leader's EI (Input), Transformational Leadership (Input), Team Cohesion (Process) and Team Viability (Output) (Fig.1).

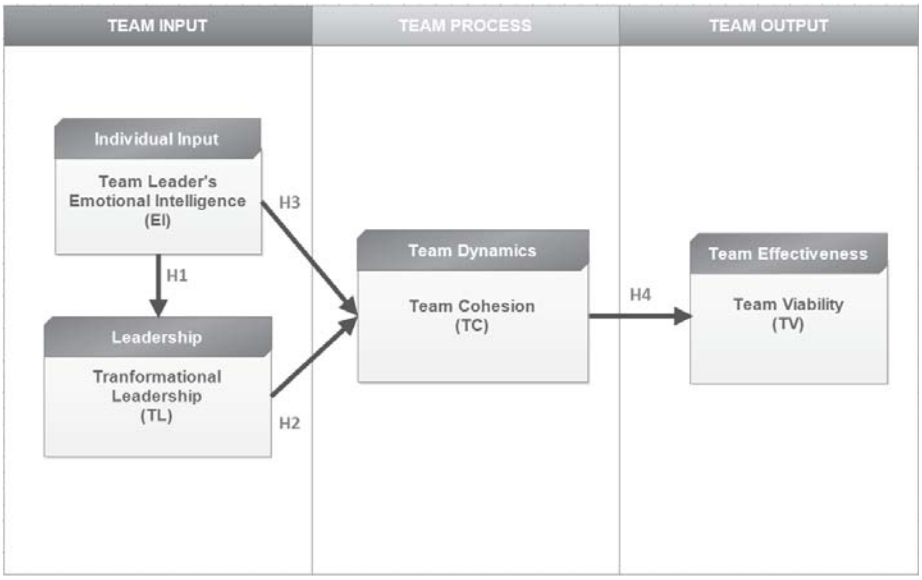

Figure 1: The conceptual model based on IPO model

This framework will be used to analyze the perception of MMOGs team players about the emotional intelligence and transformational leadership behavior of their leader. A mixed research methodology combining qualitative / quantitative data and mixed research data acquisition methods (questionnaires and interviews) will be used. MMOGs offer the opportunity to collect data remotely and anonymously, through the environment itself, or by collecting information from the players. Thus, for the purposes of the study, the data will be collected from online questionnaires, measuring team members' perception of group's leader's emotional intelligence, group's leader's transformational leadership, team cohesion and team viability. Moreover, by using questionnaires and interviews the study will examine team members' perceived transfer of these skills in their workplace settings and the main gamification elements that foster emotional intelligence and transformational leadership, team cohesion and team viability within the game.

6. Conclusion

Given the ever increasing rise of virtual work, the need to identify the individual characteristics that influence the effectiveness of a team is paramount. To this end, this paper aims to contribute to research and to bring out the emotional intelligence as a potential key to understanding the effectiveness a virtual team. More importantly, the conceptual framework of the study is an attempt to examine the relationships between factors that have been highlighted as important in the literature of different scientific areas like psychology, management and sociology and test this framework in the context of MMOGs, which have been identified as a unique arena for the spontaneous expression of personal and interpersonal behaviors and the impulsive creation of life-longing virtual teams. By exploring these relationships, transformational leadership behavior can be positively related to team-leader emotional intelligence and both these constructs can be found to be positively related to team cohesion and team viability, highlighting the importance of training emotional intelligent leaders of virtual teams. The results of the study will contribute to the limited empirical research on MMOGs and provide the theoretical basis for the design of training courses that could enhance team leader's emotional intelligence, transformational leadership and develop team cohesion and viability through game play. These findings will contribute to the final stage of this project, including the design principles for the development of an emotional intelligence training course with real, on-the-job content to teach leadership using essential gamification elements**.**

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An Investigation of Digital Games Features That Appeal to Young Females and Males

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Abstract: This research is part of an attempt to address the well-known problem of female underrepresentation in computer science education and industry. This problem starts between ages 11 to 14 and gets progressively worse in what is often referred to as the "shrinking pipeline effect". There has been considerable research into the causes of the shrinking pipeline and attempts to halt or reverse it. In spite of this, the causes remain unclear and there is evidence that the problem may be worsening. Digital games are increasingly used in education because of their ability to engage and motivate young learners. Unfortunately, digital games used in the teaching of IT and computer science have been found to appeal less to females than males. This is in spite of the fact that digital games intended for entertainment, as opposed to education, are now very popular with girls. There has been some research into this issue, however more is needed, especially into what game features do and do not appeal to girls at the age that the pipeline starts to shrink. The study reported here aims to identify what characteristics of digital entertainment games appeal to young females and males. The results can be used to guide educators, researchers and game developers and provide criteria for evaluating the suitability of digital educational games for use with specific age groups and genders. We used open card sort with participants aged 11 to 14 to explore their attitude to a range of digital entertainment games. Open card sort allows participants to categorise items in ways that are meaningful to them. There were 32 participants (24 females and 8 males) from four schools in south-east England. They were shown video clips of ten popular games. The participants were then given ten cards, each representing one of the games and asked to sort them into categories based on shared characteristics. This process elicited 131 features (95 from the females and 36 from the males). The data was analysed to identify the features that were a) most significant and b) most appealing to the participants. The findings indicate that there are some gender differences in which game features are perceived as most significant. Some features, such as game action, are significant to the males whereas others, such as game levels, are significant to the females. Interestingly, some features that both genders find significant have different degrees of appeal for example "fun" and "violence". We are currently using the findings in an experiment with 480 young people. Two digital educational games have been created: one includes features found to appeal to young females and the other includes the opposite or neutral features. The results of this experiment will be used to validate the findings of the initial investigation and form the basis for a framework to facilitate the inclusion of characteristics that appeal to specific groups in educational games and other software.

Keywords: computing education; card sort; gaming features; game appeal; gender differences

1. Introduction

The underrepresentation of females in computer science education and industry is a progressive problem, often referred to as the "shrinking pipeline effect" (Camp, 1997). It starts between late primary school years and early secondary education stages - age 11-14 (Krendl, Broihier and Fleetwood, 1989; Dryburg, 2000). Over the years, a number of intervention strategies including the use of digital educational games have been implemented to try to halt or reverse the problem.

Unfortunately, digital games used in the teaching of IT and computer science have been found to appeal less to females than males. In contrast to this trend in education, digital entertainment games are becoming more and more popular with girls. Although there has been some research into this issue, further investigation is required into what game features appeal and do not appeal to girls at the age the pipeline starts to shrink.

An attempt to improve the appeal of digital educational games to young females needs to tackle two key issues: gender-specific preference(s) (Salisch, Oppl and Kristen, 2006; Klimmt and Hartmann, 2007) and gender stereotypic game features (Huff, 2002; Heemskerk et al., 2011).

The study reported here investigates digital entertainment games rather than educational games. This is because entertainment games are successful with both genders. The aim is to identify the differences and similarities in the significant game features that appeal to 11-14 year olds. The findings will be used to create digital education games that might appeal to girls of the target age group. The research question addressed in this paper is: "*What are the differences and similarities in the significant digital game features that appeal to young females and males of age 11-14*"?

The term 'computer game' is often used interchangeably with 'video game' in related literature: the term 'computer game' being used to refer to personal computer based games and 'video game' for console-based games. In this paper, the term 'digital game' will be used to represent both usages ('computer game' and 'video game'). A digital game is defined as "*one that provides some visual digital information to one or more players; takes input from players; processes input according to a set of programmed game rules and alters the digital information provided to players*" (Kirriemuir and McFarlane, 2004, pp.6).

The rest of this paper includes an overview of relevant literature, a discussion of how the investigation was carried out and the results of the investigation. It concludes with a discussion of the results, conclusion and future work.

2. Digital game features that appeal to young females and males

Whereas a number of game features appeal to both females and males, others have been shown to appeal more to one gender and some are unappealing to the other gender (Beasley and Standley, 2002; Downs and Smith, 2010). Consequently, it would be inaccurate to assume that young females and males are passive recipients of the gaming environment we provide through software (McCartney, 1988).

2.1 Digital game features and young females

Research has identified non-violent content, significant social interaction, meaningful dialogue and non-competitive structures as key characteristics of digital games that appeal to young females (Jansz, 2005; Hartmann and Klimmt, 2006). These characteristics are associated with genres such as adventure games and puzzle-solving games. These game genres tend to have non-competitive structures that reduce time pressure and threats of failure (Lucas and Sherry, 2004). They provide immediate positive feedback which improves the level of independence during play and ensures that correct choices are made as players progress in the gaming environment (Dickey, 2007; Robertson, 2012).

In addition, young females find narrative games appealing due to their interest in storytelling (Beard and Burrell, 2010). Storytelling has been shown to provide a social platform for sharing experiences with friends and classmates. This improves female interest in games providing the opportunity for self-expression in the gaming environment, making links with real life situations and playing variety of roles (Kelleher, 2008). Likewise, the imaginative structure of the storyline gives a clear purpose to the digital game and provides opportunities for exploration rather than purely hierarchical scoring (Robertson, 2012).

2.2 Digital game features and young males

Young males have been shown to find goal-oriented games appealing as they are designed to be challenging with precise targets or outcomes. The use of game technology, such as acquiring new characters and accessories, has been identified as a common method used in the achievement of goals during game play and thus appeal to young males (Kafai, 1998; Hayes and Games, 2008).

Furthermore, it has also been reported that young males are more likely than females to play digital games for competition and challenge. This is often related to the fact that they play games for longer periods than females and thus become expert in game technologies and strategies, which boosts their confidence in their abilities. For young males mastering the game is often seen as a "social plus" within their peer group (Olson, 2010). Other studies also report that young males find action games with strategic play activities appealing (Gorriz and Medina, 2000; Kinzie and Joseph, 2008). This has been shown to be influenced by other game characteristics such as high hand-eye coordination requiring quick paced interactions. A number of game features such as game exploration, narratives and feedback have been identified as unappealing to young males because they are less goal-oriented (Bead and Burrell, 2010; Robertson, 2012).

3. Survey methodology

Our survey used an adapted version of the open card sort methodology with groups of females and males of age 11-14. Each participant was shown video clips of a selection of games. They were then asked to identify a way in which some of the games were similar to each other but different from others. For instance a participant might choose “fun”. This would be termed a “construct”. Having identified a construct the participant was then asked to order the cards representing the games into groups based on the construct. For example the participant might put the cards in three groups: lots of fun, some fun, not fun. These grouping are termed “categories”. This is done repeatedly until the participant could think of no more constructs for grouping the cards. During the sorting process, participants were also requested to verbalise the thought process captured as a “think–aloud” protocol. This process provides further qualitative insight into participants’ decision making process while sorting (Righi, James, Beasley, Day, Fox, Gieber and Ruby, 2013). At the close of each session, the participant sorted the picture cards according to their likelihood of playing the game into three groups: "Most Likely to Play", "Likely to Play" and "Never Likely to Play".

The terms game “feature” and “construct” are used more or less interchangeably in this report. The term “construct” is used where reference is made to the criteria used by participants in the study to group games that they perceived to have something in common. This technical term comes from the card sort methodology used in the study. Elsewhere the more everyday term “feature” is used.

The methodology was applied in one-to-one sessions by the researcher. This was to avoid the danger inherent in working with a group where a dominant individual might impose his or her opinion on the group. The methodology excludes constraints associated with expertise of game play and rather focuses on the game features that appeal from the video narrative and previous experience of playing similar games.

3.1 Survey materials

The materials used for the survey were 10 top game play video clips each 5-15 minutes long, selected from a variety of game genres. The video game clips were viewed on a personal computer at the start of the session.

Figure 1: A sample game play video of Toki Tori (© 2013, Two Tribes)

The videos highlighted the play environment and features of the games. 10 picture cards were designed, one for each game as illustrated in table 1.

Table 1: The card number, game genre and game title used in the picture cards

Card	Game Genre	Game Title
#1	Action	Lego City
#2	Maze	Pac-Man
#3	Adventure	Luigi’s Mansion
#4	Role Play	World of WarCraft
#5	Simulation	SimCity
#6	Strategy	Fire Emblem
#7	Arcade	Super Mario

Card	Game Genre	Game Title
#8	Music	Just Dance
#9	Puzzle	Toki Tori
#10	Casual	Angry Birds

The picture card also included an image of the game, a card number and key information about each game such as: the game plot, the game platform, player mode (single or multiple) and how scores are awarded.

The picture cards (figure 2) were of uniform size to ensure participants did not consider any one card more important than the other (Rugg and McGeorge, 1997).

Figure 2: A sample of a picture card with text (Adapted from Toki Tori)

3.2 The study sample size

A total number of 32 participants (*N=32*) of age 11-14 years old, comprising of 24 girls ($n_g=24$) and eight boys ($n_b=8$) from two girls' secondary schools and two mixed secondary schools in south-east England.

4. Results

A total of 131 constructs were initially generated by the participants (95 from the females and 36 from the males). The constructs generated were organised into super-ordinate groups and classified based on their commonality. A super-ordinate group provides a common construct name to capture the gist of several constructs (Rugg & McGeorge, 1997) as generated by the participants. An example is the super-ordinate group "Age appropriateness" which includes constructs such as "age", "age group" and "age limit". An aggregation of the constructs conducted, using a *Construct by Gender Matrix* established the agreement levels. For the male participants, game graphics, action and fun appear to have the highest levels of agreement. For the female participants the number of players, fun, age appropriateness, game violence, graphics, colour used, popularity, storyline, device, character and play levels have the highest levels of agreement. A graphical representation of both female and male constructs generated with corresponding agreement values are illustrated in figures 3 and 4.

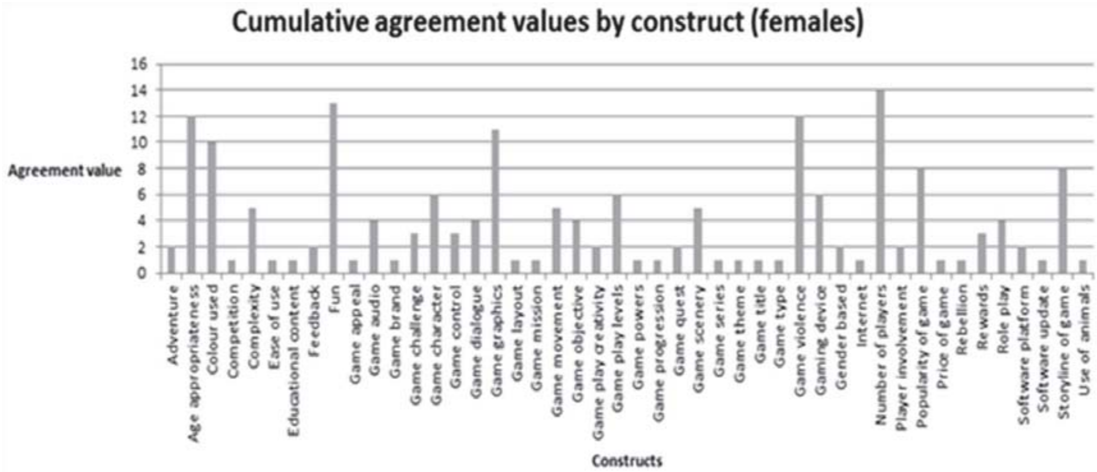

Figure 3: The agreement values of constructs from female participants

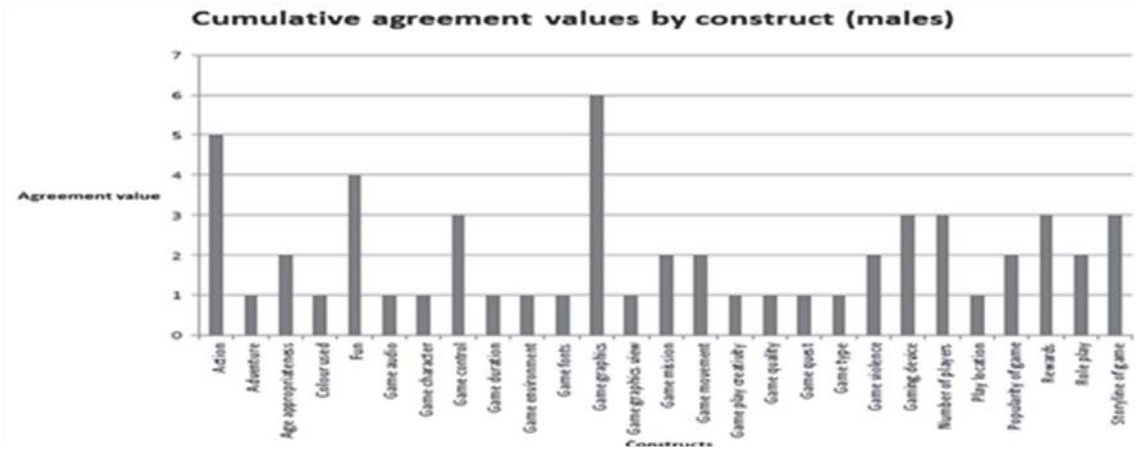

Figure 4: The agreement values of constructs from male participants

From the illustration in figure 3, the number of players, fun, age appropriateness, game violence and graphics have the highest agreement levels for female participants. The constructs with high agreement levels include colours used, popularity of game and storyline of game. For male participants in figure 4, game action, fun and graphics have the highest agreement levels. Other constructs of high agreement levels include game control, device, rewards, storyline of game and number of players. A comparative review of the results from female and male participants identified game fun and graphics as constructs of highest agreement levels with both genders. Furthermore, game storyline and number of players were also of high agreement levels between both genders.

Table 2 presents some of the "think aloud" comments for constructs with the highest levels of agreement. It is interesting that although there is agreement over the significance of some constructs between the two groups, the actual appeal differs. For example the level of violence is of significance to both groups, whereas several of the girls expressed dislike for what they perceived as too much violence.

Table 2: Female and male "think aloud" comments

Game construct	Participant comments (females)	Participant comments (males)
Number of players	*"The number of players in a gaming environment determines the level of communication which is important in a game";*	*"Multiplayer games are fun";*
	"When there a number of players, it becomes educational in a way as we can share ideas".	*"I prefer a game many people can play".*
Fun	*"How involving the game is must have levels of play and can be played by a number of people. It must not be too difficult as well";*	*"Rewards and being able to complete the game makes it fun";*
	"It provides the opportunity to interact with other people and this creates more fun";	*" There is an urge to return to a fun game";*
	"Learning something new makes playing games fun".	*"Multiplayer games are fun".*
Age appropriateness	*"There is not a lot of appeal in a game if the age is not right for me";*	*"if the game is not at my age it may be too easy or difficult to play";*
	"It (the game) becomes unchallenging if the age is not right as the game would be too easy to play";	*"I would not play a game that is not for my age group".*
	"This game has the features I would like but it is too easy to play and the graphics are similar to that for little children of age 3-9 years of age";	
	"Unappealing if the age is not right as it might be difficult and require a lot of thinking and movement".	
Game violence	*"I do not mind some violence, but a lot of it becomes off putting";*	*"I like extremely violent games".*
	"boys game";	

Game construct	Participant comments (females)	Participant comments (males)
	"I do not mind playing games with some violence, but I will not play one that is extremely violent".	
Game graphics	*"This game has the features I would like but it is too easy to play and the graphics are similar to that for little children of age 3-9 years of age".*	*"The game graphics affects the game design";*
		"The game graphics is how the game looks like".

An independent t-test analysis to determine the difference in the mean values for each game construct between genders was conducted. The hypotheses for the statistical test are as follows:

H0: There is no remarkable difference in game construct between females and males

(where H0 is the null hypothesis and p value=>0.05)

H1: There is remarkable difference in game construct between females and males

(where H1 is the alternative hypothesis and p value=<0.05)

Table 3: Statistical significance test for constructs of importance

Game construct	Gender (Female =24 Male = 8)	Mean *(M)*	Std. Deviation *(SD)*	Sig. (2-tailed)	Hypothesis accepted (H_0 or H_1)	Effect size (Partial Eta squared-R squared)
Number of players	female	.583	.504	.322	H_0	.000
	male	.375	.518			
Game fun	female	.542	.509	.844	H_0	.000
	male	.500	.535			
Age appropri ateness	female	.500	.511	.220	H_0	.000
	male	.250	.463			
Game violence	female	.500	.511	.220	H_0	.000
	male	.250	.463			
Game graphics	female	.458	.509	.156	H_0	.000
	male	.750	.463			
Game colour	female	.417	.504	.000	H_1	.089 (large effect)
	male	.000	.000			
Game popularit y	female	.333	.482	.003	H_1	.111 (large effect)
	male	.000	.000			
Game storyline	female	.333	.482	.836	H_0	.000
	male	.375	.518			
Game Device	female	.250	.442	.512	H_0	.000
	male	.375	.518			
Game character	female	.250	.442	.011	H_1	.077 (large effect)
	male	.000	.000			
Game levels	female	.250	.442	.011	H_1	.077(large effect)
	male	.000	.000			
Game action	female	.000	.000	.011	H_1	.556 (large effect)
	male	.625	.518			
Game control	female	.000	.000	.080	H_0	.000
	male	.375	.518			
Game reward	female	.000	.000	.080	H_0	.000
	male	.375	.518			

Game construct	Gender (Female =24 Male = 8)	Mean *(M)*	Std. Deviation *(SD)*	Sig. (2-tailed)	Hypothesis accepted (H_0 or H_1)	Effect size (Partial Eta squared-R squared)
Game mission	female	.000	.000	.170	H_0	.000
	male	.250	.463			

Table 3 presents the mean values (*M*), standard deviation (*SD*) and the significance (2-tailed) test value which is also the *p value* for each game feature for both female and male population. The *p value* was used to make conclusions on the statistical significance of each game construct between both genders. The game constructs with H_1 indicate remarkable difference between both genders.

In other to investigate the extent of difference the Partial Eta squared effect size test (*0.010 = small; 0.060 = moderate; 0.138=large)* was conducted. This type of effect size test is applied due to the unequal sample numbers used for the independent variable gender (female and male). From the analysis of the result, all the game constructs that are statistically different will present large effects within the population

The data about the participants' likelihood of playing each game was correlated with the constructs and categories to determine the measure of appeal. Table 4 shows a summary of the results of this analysis. Notice the "game violence" construct. This correlation of the categories identified for this construct with the likelihood of play shows that girls are likely to play games with moderate violence whereas boys are likely to play games that they perceive as very violent. This confirms the data gathered for the think aloud protocols.

5. Discussion

Table 4: Construct/categories with appeal to male and female participants

Game construct	Construct category with appeal (female)	Construct category with appeal (male)
Game graphics	Cartoons	Photographs
Fun	Lot of fun	Lot of fun
Game control	Moderate control	Full control
Gaming device	Any device	Specialised
Number of players	Multiple players	Single
Rewards	Progression	Points
Storyline of game	Good storyline	Satisfactory storyline
Age appropriateness	Specific age group	Teenage games- suited for age group
Game mission	Not based on character mission	Based on character mission
Game violence	Moderate violence	Very violent
Popularity of game	Very popular	Popular games
Colour used	Bright colours	Dark colours
Game character	Human with real scenarios	Fantasy scenarios
Game action	-	Lots of action
Game levels	Game with levels	-

Game action and game levels are evidenced to be gender-specific preferences from this study. Game action is peculiar to young males as there seems to be a preference for high hand-eye coordination requiring quick paced interactions (Gorriz and Medina, 2000). For young females the preference for game levels can be associated with the requirement for a game to be purposeful. It also encourages a non-competitive structure, exploration, less time pressure and failure threats (Lucas and Sherry, 2004).

There is another group of game features that are significant to both genders but differ in their appeal. Examples of such game features include: game graphics, fun, character, violence, control, device, storylines, mission and number of players. Female participants' preferred cartoon graphic images while the males preferred photographic images. This difference is supported in related work on computer graphics for young females and males by Jakobsdóttir, Krey and Sales (1994). The statistical significance analysis of this game feature indicates that the difference is not remarkable. Jakobsdóttir, Krey and Sales further argued that it is possible to design gender neutral graphics for the gaming environment that can appeal to both groups.

Furthermore, game fun is significant to both female and male participants. However, the game characteristics that create fun vary between genders. From the think aloud comments, game levels, number of players, exploration, progression, complexity of game and game interactivity contribute to the fun of the game for young females. For the males, it includes game violence, game action, number of players, reward and challenge makes the game fun.

The number of players is also significant to both female and male players. Both genders are community gamers but differ in how they engage with other players. Young males prefer to play in a single mode but engage with other players in the community through challenges, competition and action-oriented environments. In contrast, the females prefer collaboration in the gaming community by sharing ideas, effective communication and team play. The think aloud protocol comments further indicate that social interaction is an effective communication tool for females. Consequently, it is beneficial to ensure that the appropriate multiple player tools and a social interaction platform are included in games designed to attract females of age 11-14.

In addition, game violence is significant to females and males but varies in appeal depending on the amount of violence. Females would play games with moderate violence as indicated from the think aloud comments and likelihood analysis, while males prefer extremely violent games in most cases. The female acceptance of moderate violence is supported by Anderson (2004); Eastin (2006) and rejected by Jansz (2005); Hartmann and Klimmt (2006). Further statistical evidence from our analysis does indicate that there are no significant differences for violence between both genders. Consequently from our study, moderate game violence should not inhibit females from engaging with digital games. Other game features such as game control, device, storyline and mission differ in preference between the genders but do not significantly differ statistically.

Game colour differs significantly between females and males. Females prefer bright colours and males dark colours. Related work on effective use of colours and graphics in applications for children of age 7-14 by Naranjo-Bock (2011) and Nielsen, Smith and Tosca (2013) supported this finding. Females were identified to find bright colours appealing and males dark colours. This game feature from our study can largely affect the appeal of games between genders as $p<0.050$ and $R\ squared = 0.152$.

Finally, game character and popularity can also greatly affect the appeal of games to both genders. The females prefer games that are very popular. This provides opportunities to share ideas and information with other players. However, males prefer games that are moderately popular. There is also a difference in the preference for game characters and their use in the gaming environment. From the analysed study data, young males prefer games built around the game character such as the first person and third person games in a fantasy scenario. This may be as a result of the preference for goal-oriented and action games. Conversely, females prefer games that are not built around the character, such as life simulation games. The characters are preferably humans in a realistic setting or real life scenario due to preference for social interaction, exploration and excellent storylines.

6. Conclusion and future work

The findings of this study indicate that there are differences and similarities in the digital game features that are significant to young females and males of age 11-14. Even where there is agreement about the significance of a feature there are sometimes differences in ways that feature affects the appeal of the game. From this study, seven significant game features have been identified for further investigation: game violence, graphics, character, storyline, number of players and age appropriateness. A follow-on experiment is now in progress based on two digital educational games, which have been constructed for learning basic computer science concepts. One game includes features found to be of positive appeal to girls and the other includes the opposite or neutral features. The experiment involves 480 female and male participants of age 11-14. The participants play each game and record their experiences before and after the sessions using questionnaires. The data collected from the experiment will be analysed and used to inform the creation of a framework for the design of digital educational games.

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Computer Games for Promoting Global Awareness: Methods and Modes

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Abstract: Computer games have come a long way not only as a form of entertainment, but also as a means for changing the world for the better. An increasing number of researchers, educators and even politicians now emphasize the value of using computer games with a purpose beyond entertainment, such as education, health and social change. This article is a study into one segment of these serious games: Social impact games. The aim is to answer the following questions: What methods do these computer games use to promote global awareness to their players? And how might the chosen modes, such as images, video, narrative and procedures, contribute to the games reaching their goal? In this study, seven computer games with a goal of promoting global awareness were analyzed. The method for analysis was inspired by Consalvo and Dutton's (2006) framework for analyzing computer games qualitatively, having a theoretical and methodological foundation within game studies, and inspired by multimodal analysis. Selected findings are presented in this article, centered on the following principles which emerged from the analysis: 1) Learning on the player's terms, 2) Meaningful choices, 3) Using real-world images and video, 4) Social mechanics. Based on this, the paper will then argue that research on computer games for global awareness should not necessarily pay attention mainly to game mechanics, as some of the main methods these games use are based on images, video and more linear narrative. Lastly, the paper briefly discusses the importance of leading players from awareness to action, as a facilitator for social change. The findings in this article aim at being helpful not only to researchers within the domain of social impact games, but also to serve as a resource for designers and developers of games with the aim of creating awareness and changes in the society.

Keywords: social impact games, serious games, global awareness, empathy, multimodality, game analysis

1. Social impact games: Background and theory

Much has happened to the computer game medium since the early 1940s when academics first began experimenting with simple computer games and simulations. An interesting aspect of this development is the rise of serious games, or games with a primary purpose other than entertainment. A segment of these games are dealing with political and global issues, with a purpose of promoting awareness or attitude change. These games are often called social impact games or games for change (Flanagan 2009). The aim of this article is to explore the methods that these computer games use to promote global awareness, focusing on the principles of *learning on the player's terms, meaningful choices,* the *use of real-world images and video,* and *social mechanics.* It will continue with a discussion on how promoting awareness through computer games might be a basis for *taking action* for the cause that was promoted through the game.

According to Machin and van Leeuwen (2007), some of the most important political discourses do not take place within the news media, but in popular media such as computer games. Young people often prefer a combination of entertaining and informing media (Neys and Jansz 2010), and raising awareness about a subject has often been one of the goals of serious games. Social impact games can have different objectives. Often, their main goal is to inform players on an ongoing situation, to build support for a cause, or to trigger discussions on a subject (Frasca 2001). However, they can also be used as a means to trigger behavior change. According to Klimmt (2009), if social change is likely to occur, several processes have to occur in the player: Changes related to attitudes and belief, learning how to do the wanted behaviors, and to create motivation among the target audience. This has been a goal for several games related to sustainable lifestyles and climate change, such as Fate of the World (Red Redemption Ltd. 2010) and Precipice (Center for Digital Media 2009).

Whether the goal is to create awareness or behavior change, social impact games aims at making an impact in one way or the other. Research on the effects of computer games and their audience has both within the social sciences and humanities traditionally put much emphasis on the media effects on the user, instead of how individuals engage with the medium. Within social sciences, many researchers ask "What do games do to people?", while they within humanities often ask what meaning is made through playing games (Williams 2005). However, one of the main characteristics of computer games is their interactive nature, and it would not be possible to play a computer game without active involvement of the player. But while player interactions are central to computer games, the interactions between the player and the game are not isolated events, but done in the context of the images, animations, narrative and sound that constitutes the game – in other words, the different modes. To explore this, a useful concept is *multimodality*, a theory of communication that looks at the different resources that people use when interacting with one another, often using different artifacts and technology (Jewitt and Bezemer 2012*).* This perspective might contribute to understanding both how the game portrays the social reality that the game creators wish to change, and how the players interact with the game. As there is still little research on social impact games, and even less on the specific topic of computer games for global awareness, more research within this field is important. Conducting research using the lens of multimodality might contribute with new perspectives in this regard, which can be beneficial to game designers and researchers within the field of social impact games.

2. Research design

A qualitative analysis was conducted inspired by Consalvo and Dutton's (2006) methodological toolkit for analyzing games. This method was developed to address the need for a toolkit giving a systematic way to analyze games without losing focus on the dynamic and interactive properties of computer games. Inspired by this method, seven computer games were played and analyzed based on the following research question: "What methods do the chosen computer games use to promote global awareness?"

The games were played and analyzed by the researcher, through one or several play sessions based on the length of the game. During the analysis, either the whole game or parts of the game would be played through again one of several times, based on what seemed important for the analysis. While playing through the games, observations were recorded using observation sheets, which used a set of categories inspired by the ones used by Consalvo and Dutton in their framework. These were related to the role of objects in the game, the game's interface, interaction with NPC's, and the overall properties of the game world. Categories were added with a stronger emphasis on storytelling and character development, and for each game, categories were added or removed after a short pilot play session to be better suited to the particular game.

2.1 2.2 Analyzed computer games

The criteria for games to be analyzed were that they *stated that they aimed at promoting global awareness among their players*, in addition to being easily available to players through free, online playing, or cheap or free download options. All games had to be featured on the Games for Change (2015) webpage, preferably games that were award-winning or had received a good review score on this website. Before choosing the games for the analysis, a short preliminary play session was conducted.

The analyzed computer games, in alphabetical order, are summarized here:

- *Against All Odds* (UNHCR 2005)*:* Experience what it is like to be a refugee through different short challenges.
- *Ayiti: The Cost of Life* (Global Kids and GameLab 2006): A strategy game where the player has to manage a family living in poverty in rural Haiti.
- *Fate of the World* (Red Redemption Ltd 2010): A strategy game where the player has to make choices to save a planet in chaos.
- *Half the Sky* (Frima Studio 2013): A Facebook game developed to raise awareness for women living in oppression worldwide.
- *On the Ground Reporter: Darfur* (Butch and Sundance Media 2010): A point-and-click game where the player explores the situation in Darfur as a reporter.
- *PeaceMaker* (Impact Games 2007): A strategy game with the goal of making peace in the Middle-East.
- *Precipice* (Centre for Digital Media 2009): An adventure game based on making sustainable choices to save the planet in the future.

From analyzing these computer games, a set of methods and principles can be identified used by these games as a means to promote global awareness. Four of these methods are described and explored in the following section. First, a short summary is presented on how the findings apply to the games analyzed, before examples are given to illustrate further. This is then discussed with a basis in literature, and informed by a multimodal perspective, to explore how this might contribute to making the games reaching their goal.

3. Learning on the player's terms

The analyzed computer games give the player the opportunity to learn more about issues that are presented in the game, either through in-game information or links to external information. This is done in different ways in the game and to a different extent, with Fate of the World and PeaceMaker including much in-game content information. Against All Odds and Half the Sky, on the other hand, mainly choose to use external links and references to provide the players with an opportunity to learn more. Ayiti includes an option to learn more through the main menu, but also use in-game information, presented through events that happen throughout the course of the game. On the Ground Reporter: Darfur provides an interesting hybrid, where, among other ways, external webpages are masked as in-game information.

According to theories from a *situated cognition* perspective, learning is more effective if it occurs in a context that is relevant and meaningful, than if it happens in a non-related context (Van Eck, 2006). The games analyzed provide an example of learning principles that Gee (2007) calls *learning just in time* and *on demand*, which means that information is available to the player at the moment they need it, or when they want more information and feel they can make use of it. This is especially apparent in the strategy games PeaceMaker and Fate of the World, as the players each round has to make informed decisions related to available actions, in PeaceMaker related to politics, security and construction, or in Fate of the World related to environment, technology, resources or society.

An example from PeaceMaker can be used to illustrate this. As an Israeli Prime Minister trying to find a solution to the conflict in the Middle East, the player has the option to increase or decrease trade restrictions. If the player wants advice on how this might affect the political situation in the area, he or she might click the "Advisor" icon to see the advice of the Hawk or the Dove (figure 1), evaluating the options from different viewpoints. This might be used by the player to evaluate what might be the consequences of the different actions if they were to be executed. In addition, the player has the opportunity to access text boxes based on different groups and leaders, such as the Israeli and Palestinian public, the Yesha (Israeli Settlers' Council) or the Arab World before making decisions, in addition to seeing the levels of approval from these groups. Based on the current political situation in the game, the player's actions might have different outcomes as will be explained through text and images (figure 2).

In this game, information is available to the players at all times, giving the players tools for analyzing the situation to make informed decisions, and adjusting the outcome of the player's choices based on their ability to understand the different variables of the conflict. Compared to a textbook with information about the conflict, this gives the players an opportunity to use the information in a relevant context, as well as getting direct feedback when making decisions in the game, which will be an indicator on how well they understand this information.

Figure 1 and 2: Situated learning in PeaceMaker (ImpactGames 2007)

4. Meaningful choices

As PeaceMaker, Fate of the World and Ayiti are strategy games, making choices regarding resource management or political strategies are the core gameplay mechanics, based on interacting with the system in ways that affect the outcome of the game. However, difficult choices are also a part of the games that more closely resembles adventure games, such as Against All Odds, On the Ground Reporter: Darfur, Against All Odds and to a certain degree the casual Facebook game Half the Sky, where the players are confronted with situations where they have to make choices regarding dialogue or actions.

Against All Odds is a short, flash-based game made by the UNHCR that uses different small challenges to teach the player about the refugee experience. In one of these challenges, the player has to find a way to escape the country without getting caught. The main mechanic of this level is that the player is presented with a set of difficult choices. One example shows the player before getting on a truck with several other people to get to the border. When it becomes clear that there are too many people to fit in the truck, the player has to choose who should get off: Relatives, friends, or neighbors? (figure 3). Shortly after, the following message is presented: "Your best friend discovers he doesn't have his ID papers with him. You all risk being discovered at the road block. It is up to you what you all decide to do with him." The player is then given two choices: A) He has to get off! B) He can come. If the player chooses the first choice, and the friend is left alone, the player will be able to proceed as the rest of the people on the truck will be fine. However, if the player decides that the friend can join, they will all get caught and the player has to start the level again.

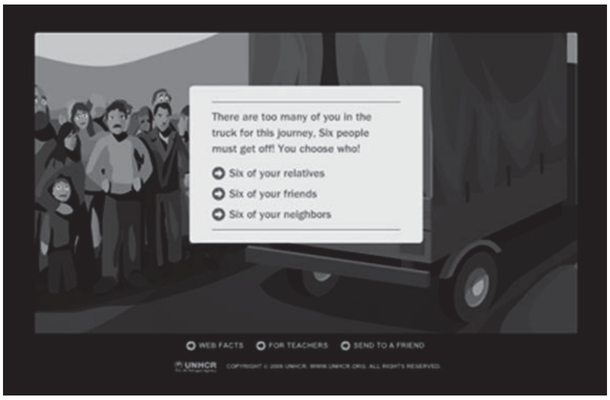

Figure 3: Making hard choices in Against All Odds (UNHCR 2005)

Game design veteran Sid Meier has been quoted saying "A game is a series of interesting choices" (Rollings and Morris 2000, p. 61). In strategy games such as PeaceMaker, Fate of the World and Ayiti, making choices is the core gameplay, as these games are based on resource management, tactics and planning. These games can also be seen as simulations, as they are representations of social or political systems in the real word, allowing the player to interact with different variables in the game and then observe the outcome (Lieberman 2009). This has often been used as a basis for serious games, as the players through a simplified system can see the effects of their actions, but within a safe environment.

The example from Against All Odds, however, belongs to a different kind of choices – moral choices. Here, the player is given a classic dilemma: Would you sacrifice your friend to keep the rest of you safe? However, the only way to progress in the game, is to abandon the friend and live with the sacrifice – allowing your friend to come will trigger a lose condition, forcing the player to start over.

Computer games are designed systems that are programmed to give the player certain kinds of experiences. Sicart (2005) argues that computer games can be analyzed as moral objects, and that the morality of computer games lies not only in what they tell, but also in how it is told. However, Sicart argues that if the choices have little or no relevance in the architecture of the game, as in this example from Against All Odds, these are not moral choices, but a morality that reflects the narrative of the game. In this case, the only way for the player to proceed in the game is to choose to not bring her friend. In a way, it can be seen as what Bogost (2007) calls "games of failure", where the designer has the intention of evoking specific feelings based on outcomes of the choices that cannot be avoided. Still, evoking specific feelings and thoughts can be a way of making the players reflect on an issue or promote empathy which might be a basis for action, both concepts that will be explored later in this article.

5. Using real-world images and video

Real-world media, such as photographs and video, is used to a varying degree in all the games, even in the games relying on drawn graphics or 3D graphics: Ayiti, Against All Odds, Half the Sky and Precipice.

PeaceMaker starts out with a video showing a compilation of news footage from 1920 until 2007, and, when playing as the Israeli Prime Minister, continues by giving a news report on a Palestinian suicide bomber killing 18 people and injuring over 100 in West Jerusalem. The player is able to watch news footage from the event, which among other elements shows the faces of grieving people. Against All Odds starts in a similar way, by showing a short compilation of footage based on being a refugee, together with the words “People you see every day, but you don’t really see them. Imagine if this were you?”. On the Ground Reporter: Darfur, uses short video clips throughout the game as a part of telling the narrative. According to Belman and Flanagan’s design principles for computer games to foster empathy, giving the players effective empathy induction when starting playing the game is a key to keep playing empathetically (Belman and Flanagan 2010). The choice to include a video compilation in the beginning of the game might be therefore be an effective choice if empathy induction is a goal.

Images are useful for evocative power, and videogames often use images as a way to use visual rhetoric (Bogost 2007). Belman and Flanagan (2010) consider the way PeaceMaker uses images, such as where Palestinian women are weeping over dead relatives (figure 4), to be an excellent way of making the players empathize on an emotional level. These images show the conflict in a personal way, adding identification in addition to the procedural representation of the political sides of the conflict. From the analysis, it also seems that real-world photographs often are used in the computer games as a way to reinforce statements that are made at crucial points in the games. In Fate of the World, photographs are used to accompany text boxes when important event happens, as can be seen in the example when the rhinoceros is extinct (figure 5). Even in Ayiti, where drawn graphics are used most of the time, photographs are used to illustrate events happening in the game, such as when a hurricane strikes the player’s home, or where one of the player-controlled characters receives an educational certificate.

Figure 4: Weeping women in a news report in PeaceMaker (Impact Games 2007)

Figure 5: The extinction of animal species portrayed by photos in Fate of the World (Red Redemption 2010)

6. Social mechanics

While all of the analyzed computer games are single-player games, connecting the players to one another is done to various degrees, and by different means. Half the Sky as a Facebook-game does this to the largest degree. Fate of the World lets the players connect through their online communities, using Facebook, Twitter, or their Steam Forum. The other games seemingly offer no direct means to connect to other players.

In Half the Sky, connecting to other players is done in several ways. First, the player has the possibility to interact with friends while playing the game. For some of the challenges presented in the game, volunteers are needed to complete them. Here, the player can choose to wait for in-game volunteers to show up, taking around an hour for each volunteer, or the player can invite Facebook-friends to join the quest. In addition, players have the opportunity to share their achievements through posting status updates on their wall, or adding to the news feed. Through a score meter, they are able to compare their own scores to the scores of their Facebook friends.

As Klimmt (2009) writes, utilizing the social dimension of computer games is one of the main mechanisms that make serious games work. Making it possible for the players to communicate about their gaming experience either through social networks or in-game, can facilitate change as it creates an arena for discussion about the subjects addressed in the game, thus illustrating Frasca’s (2001) argument for using serious games as a way to promote discussion on an important theme. In-game communication might also be beneficial, as it is possible to use conversation among the players as a way to build understanding of a subject (Klimmt 2009).

McGonigal (2011) has written from a perspective on positive psychology on how social gaming can promote well-being and help make the world a better place. Connecting to our social network for example by interacting with friends and family using Facebook games, might lead to prosocial emotions and give more meaning in our lives, as we are connecting to something bigger than ourselves. This might be a way of contributing to a common goal, in Half the Sky to empower women and girls globally.

As social mechanisms are seen as important factors for making serious games work, it is interesting to note that seemingly only Fate of the World and Half the Sky directly provides a way for the players to communicate. However, players today are part of what Jenkins (2009) calls the participatory culture, where people playing games are not only consumers of digital media, but also participate in activities such as discussing their experiences, writing blog posts and reviews, and creating content based on their gaming experiences. We see examples of this in computer games where this is not facilitated by the game developers themselves. Players discuss strategies for Ayiti on independent webpages, the games are reviewed on several private blogs, and the Games for Change (2015) website allow players to rate all of the games shown on their website.

7. Discussion

From the analysis, four perspectives seem to be especially important in games for promoting global awareness: Learning on the player's terms, meaningful choices, the use of real-world images and video, and social mechanics. Some of the games are mostly influencing the players cognitively through facilitating *learning* about a topic or helping the player to see connections between variables in a strategy game, other games are affecting the player's *emotions* through narrative and empathy induction*,* and some games utilize the power of social networks to make the players engaged in a cause. From a multimodal perspective, emotions seem to be triggered by images, video and narrative, while learning mainly occurs through procedures based on the player's actions, and through information provided through written text and hyperlinks. Through the use of different modes, the game designer has created an opportunity for the player engage in a meaningful interaction with the game, and engaging with what the game designers try to say.

An important point to notice, and that might have implications for further research, is that several of the most prominent methods that these computer games use to promote global awareness are based not mainly on game mechanics, but on images, video and narrative. Therefore, it would be beneficial to analyze not only how different modes work together when analyzing computer games for promoting global awareness, but also to go deeper into a study of each of these elements, utilizing knowledge from areas such as film theory, narratology and visual rhetoric.

While promoting global awareness could be a goal in itself, an important next step when researching methods for promoting global awareness it to examine how this might aid the game in being a facilitator for social change. Half the Sky is the only one of the analyzed games that gives the players the opportunity to take direct and immediate action, mostly through encouraging the player to donate money to a cause that has been presented in the game – like giving a donation for real vaccines after completing a health related challenge in the game (figure 6). While this is not a common feature in computer games for promoting global awareness, it is an important one. One of Belman and Flanagan's (2010) principles for designing games for fostering empathy is to give players specific recommendations about how their actions can address the issues represented in the game, and that inducing empathy without providing the players with a means to help, might have negative effects. If the players actually will take action or not, however, depends on how their current belief systems corresponds with the game – a person already believing that everyone deserves financial aid, might be more likely to donate than a person believing that everyone should be able to work hard and support themselves. This would be important to remember when facilitating taking action for a cause presented in a computer game.

Figure 6: Take action in Half the Sky (Frima Studio 2013)

8. Conclusion

In this article, seven computer games for promoting global awareness have been analyzed to explore the methods these games use for promoting their cause. I have argued that four principles are especially clear in terms of how computer games promote global awareness: Learning on the player's terms, meaningful choices, the use of real-world images and video, and utilizing social mechanics. How the different modes are used, such as narrative, procedures and visual media, impact how these methods make the game reach their goals. Research on social impact games could therefore benefit from going deeper into each of these modes, drawing on research from areas such as narratology, film theory and visual rhetoric in addition to researching the game mechanics.

While social impact games might have different aims, such as being the starting point for debate, making the players donate money to a good cause, or changing to a more sustainable lifestyle, it is important to remember that for social change to occur, the players should be given direct recommendations on how they can take action for the cause promoted in the game. However, this is not always seen in social impact games. Therefore, a topic for further research on computer games for promoting global awareness should be how these games lead the player from *awareness* to *action.*

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From Strategy (Play) to Knowledge (Learning): A Case Study

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Abstract: Games are considered relevant tools for implementing learner-centred approaches and teaching complex issues, particularly when the knowledge that enables play is also the knowledge targeting for learning (Sanchez, 2014). As a case study, we analyse the game *Mets-toi à Table!* (MTAT) This game addresses nutrition education for high-school students (Monod-Ansaldi *et al*. 2013). The most recent version of the game (adapted for touch-screen tablets) consists of a contest between two teams of players who attempt to conceal and unmask characters according to their dietary choices. The analysis of the game, carried out in the context of a 2nd year PhD thesis in Educational Science, allows us to identify indicators corresponding to the *strategy-building* phase of an appropriation model based on three stages (exploration, strategy-building and mastering) The model analyses student appropriation of the educational game MTAT, using criteria from a theoretical model in which appropriation is viewed as the student's response to the teacher handing them the responsibility of solving a problem (Pérez, 2014). This research is based on the theory of didactic situations (Brousseau, 1998) and game theory (Neumann and Morgenstern, 1944). It aims to identify the strategies enabled by MTAT from a game modelling perspective. It also aims to identify indicators of *strategy-building* by students. These indicators are required to analyse game appropriation in the classroom. As a result, the research identifies winning strategies involved in the MTAT game and, using an *a priori analysis* confirms whether or not they offer access to the *targeted knowledge*.

Keywords: didactic situation, strategy, intrinsic game, a priori analysis, nutritional education game

1. Introduction

This research is considers in the context of game design, more precisely how play strategies influence learning outcomes. This subject has already been addressed by research which states that by playing games, players solve problems so as to achieve the game's objectives. "Through trial-and-error, children learn from their mistakes and their efforts to find a solution for the problem" (McFarlane *et al*. 2002). "They develop problem solving skills and thinking skills". "Games are very suited to the development of inquiry skills; children learn by formulating hypotheses and testing them" (Vos *et al*. 2011). "A majority of students shift to a hypothetic-deductive approach and then succeed in reaching the goals of the game and in developing new procedural knowledge". (Sanchez, 2011).

The aim of this research is to identify strategies available to players in the game *Mets-toi à table!* (MTAT). Its purpose is to recognize which of these potential strategies players use, which ones allow players to master the game and therefore win, and finally, which ones allow them to master the *targeted knowledge* in the learning situation. This paper contributes to identifying strategies built by players to solve problems and the *didactic variables* that allow teachers to orient these strategies towards the *targeted knowledge*. This analysis will allow us to give the game designers/instructors a benchmark for modifying *didactic variables* in the *learning situation*. To conduct this analysis, we use *game theory* to conceptualise the MTAT game, in order to identify the strategies built by students, in comparison with the strategies the game allows to be built. Subsequently, we must verify whether the winning strategies also offer access to the *targeted knowledge*, since the theoretical *model of appropriation*.

2. Theoretical framework

2.1 Games and the construction of strategies

According to Neumann and Morgenstern (1944), a strategic situation is one in which the results of an agent's actions are dependent on what other agents do. This research uses game theory to analyse possible strategies and winning strategies in the educational game MTAT. A strategy, in this sense, is a comprehensive action plan that specifies how to behave during the game (Sánchez-Cuenca, 1944). We employ the terms *player* and *agent* synonymously.

Game theory is based on the idea that rational choices define how agents make decisions. It analyses decisions called "rationales". A rational agent acts according to his/her preferences. Preferences are reflected quantitatively through the concept of "utility" in that they represent the binary relationship between different alternatives. The *utility function* assigns numbers to preferences to measure the benefits that agents receive from the result of a performed action. The maximum value of the function is equivalent to the most preferential result. In a situation of uncertainty, the calculation of the *utility function* accounts for all the results that an action can produce. Results are then derived from a combination of actions and *states of the world*, which are the possible results of an action. The *utility function* is a method used to measure the valuation of intermediate results. The winning strategy is the one that maximizes the player's utility (Sánchez-Cuenca, 1944).

2.2 Didactic situations and didactic variables

According to Brousseau (1998) a *didactic situation* is a hypothetical game, which sets out a minimalized system of necessary conditions in which specific knowledge can be manifested through an agent's observable decisions in a learning environment. A didactic situation is organized in such a way that the *targeted knowledge* is required to solve the problem the students are confronted with. Therefore, a problem cannot be resolved without the implementation of the *targeted knowledge*. Through an *a priori analysis*, we use this theory to analyse, whether the winning strategies of the educational game MTAT are the same ones that the game designer/instructors expect students to use to construct knowledge.

Didactic variables represent characteristics of a particular *learning situation* that teachers can modify in order to impact the students' problem solving strategies, therefore enabling knowledge to be developed. When a teacher proposes a situation, he/she presents the materials, the individual or team activity, the authorised and unauthorised actions, the goal of the actions and any other elements that offer students the initial steps towards discovering possible actions that solve the problem. This process, known as *devolution*, is defined by Brousseau as the way in which a teacher transfers the responsibility of the problem resolution over students.

3. Methodology

The *a priori analysis* is a tool that was developed within the theory of *didactic situation* (Brousseau, 1998). It provides an *a priori* explanatory model of student behaviour, and raises questions about the reasons behind their actions in relation to the *targeted knowledge*. It aims to provide a rational explanation for student behaviour, in terms of their choices and strategies, as part of a process concerned with developing an understanding of the issues faced in a learning situation. It answers the following questions: what do students already know and what means are available to them? How can the questions a teacher asks or the devolution of the problem by the teacher make sense to them? What must they learn to answer the teacher's questions? The *a priori* analysis discusses the strategies which are used as the explanatory model for the procedure followed during the class experiment. One of the aims of the *a priori analysis* is to identify certain activity choices made by the teacher, as well as the alternatives and their consequences, with regard to the knowledge objectives and the potential for learning.

We have analysed the MTAT game, using a reading of the curriculum to build the *targeted knowledge* of the learning situation, in order to identify *prerequisites* in mathematics, physics, chemistry and life sciences and geography. We have answered certain questions such as: What is the issue or problem to be devolved? What should students learn to solve the problem? What is the meaning of their actions with respect to the referred knowledge? We have interviewed the game's team of designers to identify what strategies they think students will build to win the game and to learn. We have played the game and we have bserved players in order to identify strategies.

3.1 The game

The MTAT game was designed for an exploratory teaching class entitled 'S*cientific Methods and Practices '(SMP),* as part of the senior level of high school (Monod-Ansaldi *et al*. 2013). The aim of the *didactic situation* was to enable students to learn the complexity of nutritional practices, taking into account scientific knowledge related to environmental, sociocultural and health issues surrounding food. Using a touch-screen tablet students are given access to a series of digital documents (i.e. texts, images, database) containing scientific information about the functions of the human body, nutrition, ecology, diseases and also sociocultural aspects related to food. In addition, students have access to assorted information from food packaging.

Using the information obtained from consulting these documents, students compile several clues to mask a randomly assigned character using the tablet programme. These features can correspond to physical categories such as age, height, weight and the intensity of physical activity, personal preference categories like consumer attitudes, type of sport and tastes, or environmental and sociocultural categories such as religion, human development index and the food model, and finally, category constraints related to purchasing power, metabolism and food allergies.

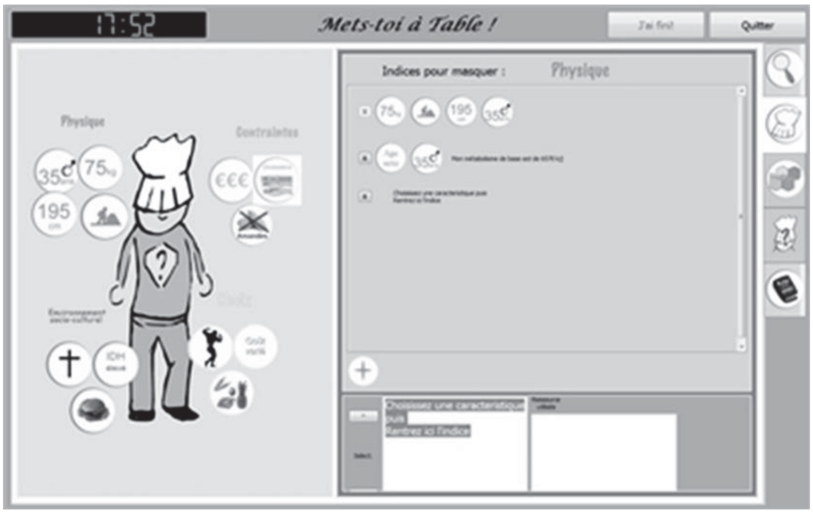

Figure 1: The MTAT game interface

The MTAT game is played by two adversary players (here the term *players* should be understood as a team consisting of either one or a pair of students). The game is organized in two timed rounds, the first one lasting 30 minutes, during which each player masks the features of a character, by compiling several clues using information consulted in available documents. None of the players know which character their opponent has hidden, nor this character's features, the clues compiled by their opponent to hide these features, or the documents consulted by their adversary to compile clues. The second round lasts for 20 minutes, in which players have two blocks of ten minutes to unmask the features of the opposing team's character. The team that discovers the most features of the opposing team's character wins. The rules of the game are explained to the students at the beginning of the challenge, throughout the game, players must consult documents that contain the information used to compile the clues. For example, if players want to mask the weight feature, to do so they can consult document number 5 named "Mass and weight". They can then compile a clue such as "I am made of 74,750.8 moles of nucleons".

In the second phase of the game, each player receives clues compiled by their opponent. They throw a dice to move around a hexagonal grid (Fig. 2). Each of the grid cells corresponds to a category that groups together a character's features. When a player validates a targeted cell he/she receives one of their opponents' masked clues, players then consult the documents to find the information their opponents have used to compile clues, eventually unmasking the feature masked by their opponent. If the opponent has no masked features in the validated category, the game offers the player the characteristics of particular features that have not been masked by the opponent. The exact same process is completed simultaneously by the opposing player, with the first player also handing his/her opponent the masked clues when they validate a targeted cell. Neither player knows what characteristics have or have not been masked by their opponent, nor do they know the number of clues that their adversary has compiled for each hidden feature. Both players can choose which clue to give to their opponent when he/she has compiled several clues for one feature.

For example, players throw the dice and move three spaces landing in the Choices category case. They receive the clue: "I prefer to use ladybirds to kill aphids" and they consult document number 12 (Eating organic). They then conclude that the character feature is "organic".

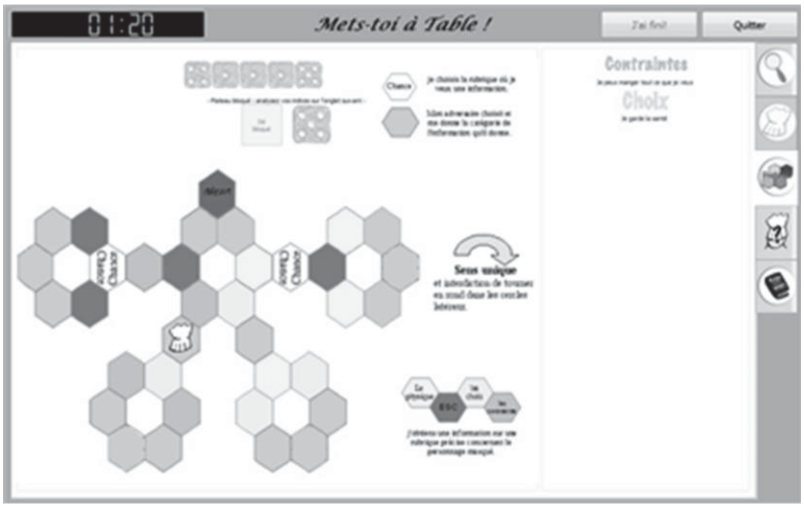

Figure 2: The MTAT game board

The third phase of the game is dedicated to unmasking the opposing player's character by using the clues obtained from the previous phase. The player must choose all the features of their opponent's character to be able to unmask it and thus obtain the game's final report (Fig. 3).

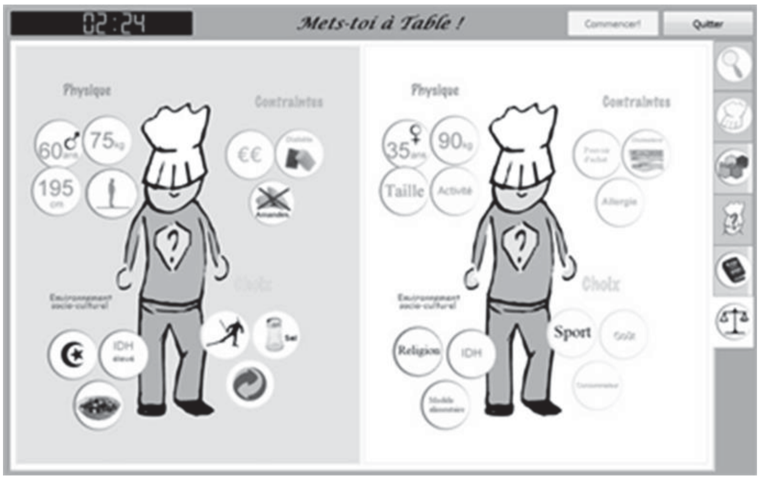

Figure 3: The MTAT game's final report

4. The *a Priori* analysis of the game

4.1 Possible strategies and winning strategies of the MTAT game

4.1.1 Actions

Two situations delimit the players' courses of action. The first one is related to avoiding the opponent unmasking their character, to achieve these players identify certain potential available actions, such as:

- Use only one document containing information about all categories to compile clues that correspond to several categories in the least amount of time.

For example, players use only document 17 "Organic eating" to compile all the clues in the "Choice" category.

- Use documents containing complex calculations to compile several difficult clues needed to unmask the character.

For example, players must consecutively use document 5 "Mass and weight", 32 "Length measurements", 2 "The Basal Metabolism", and 4 "Protein Needs according to types of sport" to compile clues.

- Compile several clues per feature, in order to give opponents the least amount of clues possible for other features (in the category).

For example, players have compiled several clues related to the organic feature:

"I do not consume fruits and vegetables from all geographical origins"

"I only consume food from neighbouring areas"

"I do not consume tomatoes the whole year long, if they are imported from other countries"

The second situation is related to unmasking the character of the opposing team, to achieve players theses identify several possible actions available to them, such as:

- Check all the grid's cells to find the opponent's unmasked or partially masked categories, so as to obtain the features within.

For example, players throw the dice and they move three spaces landing in a case related to the Physical category (blue cell). They receive clues: "I measure around 2.133 yards". They throw the dice and move five spaces landing in a case related to the Choice category. Here, they automatically receive the Sport (endurance) feature because their opponent did not compile any clues related to this category.

- Initially validate cells corresponding to categories perceived as having a low-level of difficulty, in order to obtain the highest amount of clues in the shortest possible time.

For example, players prefer to land in cases related to the Socio-Cultural Environment (red cell) to receive clues related to the Religion feature, because in documents containing religion information they can also find some sentences they can use for clues.

4.1.2 States of the world

For each of the player's actions there are two possible opponent-player responses (*states of the world* for which the player is uncertain). In Tables 1 and 2, we can see the actions and the *states of the world* of the situations".

Table 1: Actions and *states of the world* corresponding to the game situation: Avoid the opponent unmasking your character

Player action	Possible opponent response 1 Validated cells correspond to action	Possible opponent response 2 Validated cells do not correspond to action
Use only one document containing information about all categories to compile clues that correspond to several categories in the least amount of time	The opponent validates a cell whose features were masked using the document	The opponent validates cells whose features were not masked with the document
Use documents containing complex calculations to compile several difficult clues to be unmasked	The opponent validates cells corresponding to categories containing calculations	The opponent validates cells that do not correspond to categories containing calculations
Compile several clues per feature, in order to give opponents the least number of clues possible for other features (in the category)	The opponent repeatedly validates a cell corresponding to the same category	The opponent validates cells corresponding to different categories

Table 2: Actions and *states of the world* corresponding to the game situation*:* Unmask the character of your opponent

Player action	Possible opponent response 1 Masking corresponds to the action	Possible opponent response 2 Masking does not correspond to the action
Check all the grid's cells to find the opponent's unmasked or partially masked categories to obtain their features	The opponent has some unmasked or partially masked categories	The opponent has masked all categories

Player action	Possible opponent response 1 Masking corresponds to the action	Possible opponent response 2 Masking does not correspond to the action
Initially validate cells corresponding to categories considered of low-level difficulty, to obtain the highest number of clues in the least time possible	The opponent has complied easy clues to unmask	The opponent has masked characteristics considered easy, with clues that are difficult to unmask

4.1.3 Preferred results

The game's best expected result can be expressed in terms of time, in that the player is able to save time, while making their opponent lose time. Conversely, the worst expected result is that in which the player loses more time than his/her opponent gains.

If a player uses only one document to mask as many features as possible by category, and their opponent validates the cells containing features masked using the information from the same document, then the player will gain time and the opponent will not receive features that the player did not mask. Therefore the player will be considered "*outstanding"*. If instead, the opponent validates cells corresponding to categories not masked using the same document, perhaps because the player was forced to use another document (therefore spending more time) or because the player did not mask the feature, then the opponent will receive the player's unmasked feature, meaning the player will be "*disadvantaged"*.

If the player uses documents containing calculations to make things more difficult for his/her opponent, and the opponent validates categories corresponding to cells whose the clues require calculations to be unmasked, the player will not have gained a lot of time but he/she will use up more of their opponent's time, so the player will be "*balanced".* If instead, the opponent validates cells not corresponding to categories containing calculations, the player will have lost time and the opponent can unmask features whose clues are easier to unmask or receive unmasked features, therefore meaning the player will again be "*disadvantaged"*.

If the player compiles several clues per feature to give his/her opponent clues for the same feature and the least number of clues possible per category, and the opponent validates a series of cells corresponding to the same category, the player will not have gained a lot of time, however he/she causes the opponent to lose more time preventing him/her from unmasking all the features for the same category, therefore meaning the player will be "*balanced".* If instead the opponent validates cells corresponding to different categories, the player will not lose a lot of time because if even if the opponent obtains the clues corresponding to different categories, he/she will not be able to unmask more than one feature by category at a time, so the player will be "*balanced".*

If the player checks all the grid's cells in order to discover their opponent's unmasked or partially masked categories to obtain their features, and their opponent has partially masked categories, the player will have gained time obtaining their opponent's unmasked features, therefore making the player "*outstanding".* If instead the opponent has masked all categories, the player will not gain a lot of time obtaining the opponent's masked clues, therefore the player will be "*balanced".*

If the player firstly validates cells corresponding to categories considered to have a low-level of difficulty, in order to obtain the largest number of clues in the shortest possible time, and the opponent has compiled easy clues to be unmasked, then the player will gain time, meaning she/he will be "*outstanding".* If instead the opponent has masked characteristics perceived as easy with clues that are difficult to unmask, then the player will lose time, meaning she/he will be "*disadvantaged".*

In Tables 3 and 4 we can notice the relationship between preferred results. We have numerically defined the preferences so as to later calculate their *measure of utility*: *Outstanding* = X_1, *Balanced* = X_2 and *Disadvantaged* = X_3

Table 3: Preferred results corresponding to the situation: avoid your opponent unmasking your character

Player action	Possible results 1 Validated cells correspond to the action	Possible results 2 Validated cells do not correspond to the action
Use one document containing information on all categories (a_1)	Outstanding (X_1)	Disadvantaged (X_3)
Use documents containing complex calculations (a2)	Balanced (X_2)	Disadvantaged (X_3)
Compile several clues per feature (a_3)	Balanced (X_2)	Balanced (X_2)

Table 4: Preferred results corresponding to the situation: unmask the character of your opponent

Player action	Possible results 1 Masking corresponds to the action	Possible results 2 Masking does not correspond to the action
Check all the grid cells to find unmasked or partially masked categories (a_4)	Outstanding (X_1)	Balanced (X_2)
Initially validate cells corresponding to categories considered of low-level difficulty (a_5)	Outstanding (X_1)	Disadvantaged (X_3)

4.1.4 Measures of utility

The measure of utility is an expected value that measures all possible values of a random variable.

Using the preferred results we will assign values to the preferences. It is useful to measure the valuation of the intermediate result (balanced). The value of X_2 (balanced) utility is calculated using a *lottery* that takes into account the best and the worst results in a scale between 1 and 0, where the best result *outstanding* = 1 and the worse result *disadvantaged* = 0. (Sánchez-Cuenca, 1944)

$U(X_1) = 1$ $U(X_3) = 0$
$U(X_2) = 0{,}6x1 + 0{,}4x0 = 0{,}6$
Then the intermediate result *balanced* = 0.6
0,6 being the probability to obtain the best result
0,4 being the probability to obtain the worst result

We also assign values to probabilities, assuming a lottery with a higher probability (80%) to be *outstanding* and a lower probability (20%) to be *disadvantaged*:
Validated cells correspond to the action = 0.8
Validated cells do not correspond to the action = 0.2
Masking corresponds to the action = 0.8
Masking does not correspond to the action = 0.2

4.1.5 Expected utility (EU) by action

EU(Using only one document containing information about all categories) = p(Validated cells correspond to the action) U(outstanding)
+ p(Validated cells do not correspond to the action) U(disadvantaged)
When replaced, EU (Using only one document containing information about all categories) = 0.8*1+0.2*0 = 0.8

EU(Using documents containing complex calculations) = p(Validated cells correspond to the action) U(balanced)
+ p(Validated cells do not correspond to the action) U(disadvantaged)

When replaced, EU (Using documents containing complex calculations) = 0.8*0.6 + 0.2*0 = 0.48

EU(Compiling several clues per feature) = p(Validated cells correspond to the action) U(balanced) + p(Validated cells do not correspond to the action) U(balanced)
When replaced, EU(Compiling several clues per feature) = 0.8*0.6 + 0.2*0.6 = 0,6

EU(Checking all the grid cells to find unmasked or partially masked categories)= p(Masking corresponds to the action) U(outstanding) + p(Masking does not correspond to the action) U(balanced)
When replaced, EU(Checking all the grid's cells to find unmasked or partially masked categories) = 0.8*1 + 0.2*0.6 = 0.92

EU(Initially validating cells corresponding to categories considered of low-level difficulty) = p(Masking corresponds to the action) U(outstanding) + p(Masking does not correspond to the action) U(disadvantaged)
When replaced, EU(Initially validating cells corresponding to categories considered of low-level difficulty) = 0.8*1 + 0.2*0 = 0.8

4.1.6 Winning strategies

The highest *expected utility* occurs when the player uses only one document containing information about all categories (0.8). It also occurs when the player, in order to unmask the character of their opponent, checks all the grid's cells to find unmasked or partially masked categories (0.92).

4.2 Strategies offering access to the targeted knowledge

4.2.1 Knowledge targeted for learning

The purpose of conducting the SMP program in senior high-school is for students to learn how to conduct research assisted by digital tools, how to apply specific techniques and implement calculations. In addition, they learn how to reason, demonstrate, explain and communicate results, in relation to aspects of health, food, sport and other major issues of society, such as contemporary global and human-related issues. This is to help them learn to exercise their own responsibility with regard to health and environmental sustainability, to learn about historical perspectives and scientific knowledge, and to analyse how complex products or systems meet individual and societal needs. Identifying the information necessary to make decisions about nutrition (the functioning of a healthy or sick human body, energy needs related to physical activity, the energy supplies and consumption constraints of certain foods, health and sport, ecological issues of food consumption and production, and finally, the sociocultural aspects that influence decisions regarding food). This approach allows students to consider how this information can be used to characterize food practices (i.e. understanding the relationship between diet and physical activity, diet and health, responsible production/consumption and environmental impact, cultural diversity and eating habits). In the table 5 we show the dimensions of the knowledge present in the documents consulted during the game. In the tables 6 and 7 we show the access to the targeted knowledge by action.

Table 5: *Targeted knowledge* in the MTAT game

Identifying information	Documents associated
Functions of the human body	1: The body mass index 2: The basal metabolism 5: Mass and weight 7: Calculation of metabolism by activity 25: Carbohydrate Index 32: Length measurements
Energy requirements according to physical activity	4: Protein needs according to types of sport 6: The proportions of LPG (Carbohydrate-Protein-Fat) 8: Proportions of LPG 18: Milk 26: Molecular cooking and diet 27: Alcohol 29: Visible/invisible fat 30: Proteins 31: Vegetable and animal proteins

Identifying information	Documents associated
	33: Lipids 36: Fatty acids 37: Unsaturated fatty acids (cis/trans) 38: Carbohydrates 39: Biscuits, chocolate, pasta and pastries, palm oil or butter? 40: Food, nutrients and energy 44: Sweeteners 60: Carbon and topological skeleton writing 61: Nutritional information labels 62: Ternary diagram
Consumer constraints on health	23: The kitchen uses of almonds 24: Diabetes: a glucose regulation disease 34: Food and cholesterol (1) 35: Cholesterol and Cardiovascular disease 64: Tastes
Ecological issues of consumption and food production	9: Shopping with the seasons 11: The ecological footprint 12: Eating organic 15: Packaging: the example of coffee 16: List of producers 17: Ecological eating 19: Eggs
Socio-cultural aspects that influence decision making in food	10: Religious practices and food 13: Vegetarianism/veganism 63: Menu 65: The human development index 66: The food model 67: Purchasing power

Table 6: Actions and knowledge access corresponding to the situation: *Avoid your opponent unmasking your character*

Actions	Knowledge access
Use only one document containing information about all categories, to construct clues corresponding to several categories in the least amount of time	Although the document contains information on different food-related categories, the knowledge is restricted to only one document
Use documents containing complex calculations to compile several difficult clues to unmask	Only 6 of the 67 available documents contain calculations, therefore this action is restricted to the knowledge contained in the available documents.
Compile several clues per characteristic to give the least number of possible clues for the same feature	Compiling several clues per feature forces students to manipulate several aspects of the same feature and to explore different documents

Table 7: Actions and knowledge access for the situation: *Unmask the character of your opponent*

Action	Knowledge meaning
Check all the grid's cells to find the opponent's unmasked or partially masked categories to obtain their features	Allows for the opportunity to learn from several documents when masked categories are deciphered by consulting many documents
Initially validate cells corresponding to categories considered to be of low-level difficulty, to obtain the highest number of clues in the least time possible	The perception of a low-level of difficult can be associated with knowledge previously mastered by the student and not knowledge being targeted for learning

5. Conclusions and perspectives

It is clear from the results that the winning strategy which requires a player to use only one document with information on all categories, does not allows the learner to explore different documents and to manipulate multiple aspects of the same feature. Conversely, when the winning strategy corresponds to the player checking all the grid's cells to find the opponent's unmasked or partially masked categories to obtain their features, this favors accessing the *targeted knowledge*, since this action enables the opportunity to learn from multiple documents as masked categories are deciphered by consulting many documents.

In this article we have conceptualised the MTAT game using *game theory* and, in doing so, we have identified both possible strategies and winning strategies. We attempted to identify the strategies that allowed access to the targeted knowledge by using an *a priori analysis*. Teachers lead students to learn using the MTAT game in the learning situation, constructing game strategies that promote documentary investigation, alongside the acquisition of vocabulary and scientific knowledge linked to food. This approach has allowed the game designer/instructors to modify certain variables in the didactic situation, so that students access the *targeted knowledge* through their motivation to win. This analysis contributes towards modifying didactic variables to direct players towards building winning strategies, which in turn allow them to access targeted knowledge.

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Towards Social Network Support for an Applied Gaming Ecosystem

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Abstract: The EU-based industry for non-leisure games (applied games) is an emerging business. As such it is still fragmented and needs to achieve critical mass to compete globally. Nevertheless its growth potential is widely recognized and even suggested to exceed the growth potential of the leisure games market. The European project Realizing an Applied Gaming Ecosystem (RAGE) is aiming at supporting this challenge. RAGE will help to seize these opportunities by making available an interoperable set of advanced technology assets, tuned to applied gaming, as well as proven practices of using asset-based applied games in various real-world contexts, and finally a centralized access to a wide range of applied gaming software modules, services and related document, media, and educational resources within an online community portal called the RAGE Ecosystem. Besides this, an integration between the RAGE Ecosystem and relevant social network interaction spaces that arranges and facilitates collaboration that underlie research and development (R&D) as well as market-oriented innovation and exploitation will be created in order to support community building as well as collaborative asset exploitation of the contents of the Ecosystem. In this paper we will outline a conceptual approach exploring methods to first of all integrate content management and community collaboration support portal technologies based on Digital Library (DL), Media Archive (MA), and Learning Management System (LMS) infrastructures with social network support technologies. This will allow for a seamless integration of social network advantages within community portal operation. On the other hand it will support information, content, and knowledge sharing, as well as persistency of social interaction threads within Social Networking Sites (SNSs) that are connected to the RAGE Ecosystem. The paper reviews possible alternative architectural integration concepts as well as related authentication, access, and information integration challenges. In this way on the one hand a qualitative evaluation regarding an optimal technical integration approach is facilitated while on the other hand design approaches towards support features of resulting user interfaces are initiated.

Keywords: applied games, social network environments, digital ecosystem, data sharing, access and information integration, integration architectures

1. Introduction and motivation

The EU-based industry for non-leisure games (applied games) is an emerging business. As such it is still fragmented and needs to achieve critical mass to compete globally. Nevertheless its growth potential is widely recognized and even suggested to exceed the growth potential of the leisure games market. The European project *Realizing an Applied Gaming Ecosystem (RAGE)* (RAGE, 2015) is aiming at supporting this challenge. RAGE will help to seize these opportunities by making available an interoperable set of advanced technology assets, tuned to applied gaming, as well as proven practices of using asset-based applied games in various real-world contexts. This will be achieved by enabling a centralized access to a wide range of applied gaming software modules, services and related document, media, and educational resources within an online community portal called the *RAGE Ecosystem*. Furthermore, the RAGE project aims to boost the collaboration of diverse actors in the applied gaming environment. Therefore, the main objectives of the RAGE Ecosystem are to allow its participants to get hold of advanced, usable gaming assets (technology push), to get access to the associated business cases (commercial opportunity), to create bonds with peers, suppliers and customers (alliance formation), to advocate their expertise and demands (publicity), to develop and publish their own assets (trade), and to contribute to creating a joint agenda and road-map (harmonization and focus).

This means, that seen as a whole the RAGE project is a technology and know-how driven research and innovation project. Its main driver is to be able to equip industry players (e.g. game developers) with a set of technology resources (so-called *Assets*) and strategies (i.e. know-how) to strengthen their capacities to

penetrate a market (non-leisure) which is new for most of them, and to consolidate a competitive position in it. Figure 1 represents the positioning of the project in the spectrum from 'theory to application'.

Figure 1: Technology and Know-How transfer (RAGE, 2015)

In consequence, the RAGE Ecosystem and its integration with social networks of game- developing- , gaming-, and applied-gaming communities will on the one hand become an enabler to harvest community knowledge and on the other hand it will support the access to the RAGE Ecosystem as a knowledge resource for such communities. As *Game-Based Learning (GBL)* communities are applied gaming communities, too, they are also representing target communities of the RAGE Ecosystem. In more detail, GBL communities are interested in games and the effectiveness of learning activities supported by GBL technologies and application scenarios.

Therefore, within the remainder of this paper the focus is on supporting content and knowledge management, community building, and collaboration in the RAGE ecosystem. Accordingly, the corresponding research question addressed in this paper is: How is such knowledge captured or developed and how can such knowledge be shared, maintained and utilized? To ensure the capturing, sharing, and exchange of knowledge, the RAGE Ecosystem will first of all be instantiated through its social dimension supporting content and knowledge management (including education and training), collaboration, annotation, creativity, and matchmaking. Besides content and knowledge management, the RAGE Ecosystem will later also support Social Network Analysis (SNA) by means of applying technologies supporting Natural Language Analysis (NLA) for discourse analysis as well as Named Entity Recognition and Semantic Representation and Annotation. This will enable users to extend the envisioned Ecosystem with features of a social mediation engine going beyond content syndication, i.e., it will serve as a social space that mediates collaboration partners, while content remains the main attractor. Finally, an interactive map of supply- and demand- side stakeholders and resources will be provided for orientation and access support.

The remainder of this paper will first of all provide a short introduction of a set of exemplar target communities. It will then review the integration possibilities of social network technologies and their interfaces that could possibly support an integration with the RAGE Ecosystem. Furthermore, it will investigate how to support access to resources and assets from SNSs. In addition, it will outline design approaches towards supporting users in the target communities by services provided by the RAGE Ecosystem by means of outlining several use case scenarios for using *Social Networking Features (SNFs)* within the RAGE Ecosystem user interface. Finally, it will present conclusions and future work.

2. Target user stereotypes and corresponding exemplar SNS user communities

As outlined above, the EU-based industry for applied gaming is an emerging business which is still fragmented and needs to achieve critical mass for global competition. The applied gaming industry and developer groups want to keep their developments innovative, i.e., attractive and technologically in good condition. These groups already have a very good understanding of their competitive advantage and corresponding assets (e.g., software, documents, and media objects etc.). However, they also need innovative ideas to develop innovative applied games in order to stay competitive. Therefore, they look for possibilities to cooperate with applied gaming research groups. Besides this, the applied games that researchers create within research projects produce a lot of applied gaming research assets and prototypes which need to be fully developed and deployed by applied gaming software developers to become marketable. Apart from applied game developers and researchers there are also applied game customers and players who on the one hand want to learn about or contract the development of applied games and on the other hand can also contribute to the development of applied game usage scenarios. Many of these communities (applied game developers, researchers, customers and players) are already fragmented into groups in several SNSs. Table 1 displays some examples of such communities in, e.g., LinkedIn and Twitter.

Table 1: Examples of applied game communities in social networking sites

LinkedIn	members
(Serious Games Group, 2015)	5.103
(Serious Games Research, 2015)	1.430
(CAREERS IN GAMES , 2015)	45.437
(People in Games , 2015)	37.342
(World Gaming Executives, 2015)	26.748
(Games Producers, 2015)	7.983
(Names in Games, 2015)	7.335

Twitter	followers
(Serious Games, 2015)	1.201
(Gamification , 2015)	15.500
(Learning Games , 2015)	6.135
(Games and Learning , 2015)	1.753
(Game Based Learning , 2015)	3.656
(Game. Play. Learn! , 2015)	1.277

RAGE will help to overcome this fragmentation and aims to exchange knowledge through its Ecosystem. Therefore, the integration of SNEs hosting such target communities with the RAGE-Ecosystem and at the same time enabling the connectivity between SNEs and the RAGE-Ecosystem will connect research-, gaming industry-, intermediary-, education provider-, policy maker- and end-user communities. Furthermore, it will facilitate the centralized access to the valuable assets beyond the SNEs.

3. Relevant starting points within the state of the art in science and technology

SNS were defined as "Internet or mobile-device based social spaces designed to facilitate communication, collaboration, and content sharing across networks of contacts. SNS allows its users to become content creators and content consumers at the same time, thus allowing instant participation, sharing of thoughts or information and personalised communication" (Childnet International, 2008).

Furthermore, SNSs have changed the way of information sharing and learning processes by adding innovative features to social communication. Therefore, SNSs are becoming increasingly important. This holds especially true for various SNFs like, e.g., rating, commenting, tagging, chatting, liking, posting new content, following actors or celebrities, playing games etc. These SNFs are not only entertaining and exciting but also useful for learning and for information enrichment. Research has shown that distance education courses are often more successful when they develop communities of practice (Barab, 2000). Furthermore, GOLBECK (2010) performed a study over a two-year period of collecting data on every social network he could identify. He also gathered daily information on thirteen networks over a 47-day period to understand how networks grow and change. This study indicates that the way, how people communicate and share their experience, interests, and information over SNEs, is becoming more and more popular (GOLBECK, 2007)].

Today, most SNSs provide application programming interfaces (APIs) for developers to integrate the SNSs into their systems. Although, the SNEs are different in their functionality, i.e., their SNF support, their software architecture for the communication with distributed other systems is similar. Most of the SNEs offer REST API (Gero Decker, 2009) (Mangler J., 2010) which can be used for integration with other systems. In the following, the description of the LinkedIn REST API software architecture will be cited as an exemplary, illustrative, and at the same time representative example. "LinkedIn has become a powerful content platform, with B2B marketers telling us that half *of the traffic they receive from social networks comes from LinkedIn. Make sure your content reaches an audience of professionals who are looking for relevant articles and information. The REST API is the heart of all programmatic interactions with LinkedIn. All other methods of interacting, such as the JavaScript and Mobile SDKs, are simply wrappers around the REST API to provide an added level of convenience for developers. As a result, even if you are doing mobile or JavaScript development,* *it's still worth taking the time to familiarize yourself with how the REST API works and what it can do for you. … The following features can be accomplished with the LinkedIn self-service APIs and mobile SDK: Sign in with LinkedIn, Apply with LinkedIn, Share on LinkedIn, Manage Company Pages. … One of the most important LinkedIn APIs is the share content on LinkedIn. There are two methods for sharing content via the REST API. The API endpoint is the same, regardless of the method you choose — only the format of the request body differs*.

- Post a comment that includes a URL to the content which should be shared— LinkedIn analyzes the included URL and automatically identifies the title, description, image, etc.
- Share with specific values — developer should provide the title, description, image, etc., directly via the parameters of the API call" (LinkedIn, 2015).

Table 2 displays the API attributes and their values which can be included in the request body and Figure 2 displays a coding example for sharing content with specific values on LinkedIn (LinkedIn, 2015).

Table 2: Attribute and values of the LinkedIn request body (LinkedIn, 2015)

Attribute	Field Description	Max Length (chars)
Content	A collection of fields describing the shared content.	
Title	The title of the content being shared.	200
Deskription	The description of the content being shared.	256
Submitted-url	A fully qualified URL for the content being shared.	n/a
Submitted- image-url	A fully qualified URL to a thumbnail image to accompany the shared content. The image should be at least 80 x 150px for best results.	n/a
Comment	A comment by the member to associated with the share. If none of the above content parameters are provided, the comment must contain a URL to the content you want to share. If the comment contains multiple URLs, only the first one will be analyzed for content to share.	700
Visibility	A collection of visibility information about the share.	
Code	One of the following values: Anyone: Share will be visible to all members. Connections-only: Share will only be visible to connections of the member performing the share. This field is required in all sharing calls.	n/a

```
{
    "comment": "Check out developer.linkedin.com!", "content": {
        "title": "LinkedIn Developers Resources",
        "description": "Leverage LinkedIn's APIs to maximize engagement", "submitted-url":
        "https://developer.linkedin.com",
        "submitted-image-url":"https://example.com/logo.png"
    },
    "visibility":    {    "code":
        "anyone"
    }
}
```

Figure 2: Sharing content with specific values on LinkedIn (LinkedIn, 2015)

In summary, it is a big advantage to aim at supporting the integration of SNFs through their REST API into the RAGE Ecosystem (AGE). This will on the one hand facilitate to extend the envisioned RAGE Ecosystem with features of a social mediation engine going beyond content syndication, i.e. it can serve a social space that mediates collaboration partners, while content remains the main attractor. On the other hand it focuses on identifying collaboration opportunities between individuals and among groups, to support matchmaking and collaboration between stakeholders, and to identify and provide support for innovation opportunities and creativity efforts. That allows communities (such as technology providers, game developers and educators, game industries, researchers) to create their own assets and post them to the Ecosystem's repository without major effort. Besides, social network analysis and discourse analysis could be conducted and used to feedback relevant information to the communities. This feedback can e.g. first help gaming companies to develop new markets in applied gaming.

4. Integration approach and methodology

The following section presents the main technical integration possibilities in the backend as well as in frontend. In this way, our integration approach and methodology is enabling us to differentiate between how to get access to resources and assets in the RAGE Ecosystem from external SNS communities and how to push contents from the RAGE Ecosystem to the external SNSs in order to improve user acceptance of services provided by the RAGE Ecosystem. Figure 3 displays the concept of a bi-directional integration approach of the RAGE Ecosystem with SNSs using a REST API.

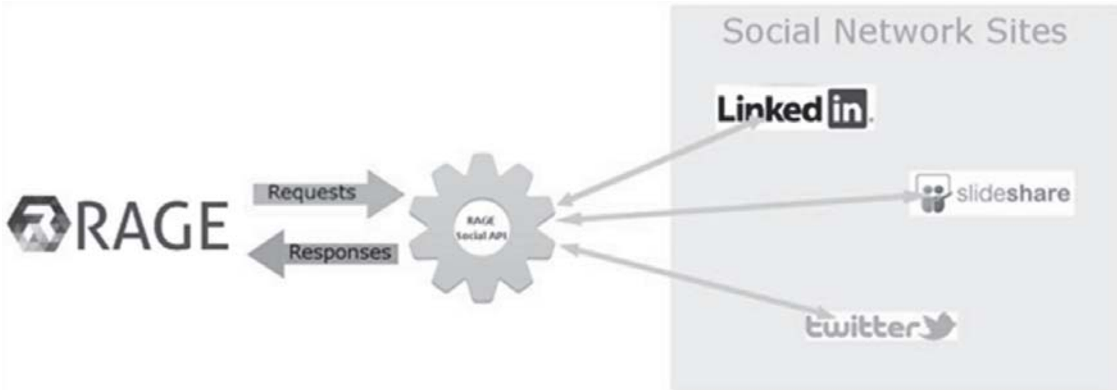

Figure 3: Integration approach of RAGE ecosystem with SNSs

Corresponding to this bi-directional integration approach, table 3 details scenarios following possible Tight and Loose Coupling (Suxia Liu, 2004)methodologies that have to be considered for achieving an integration of SNS to RAGE and vice versa.

Table 3: Loose and tight coupling integration methods between SNS and the RAGE ecosystem

Method	FROM SNS TO RAGE ECOSYSTEM	FROM RAGE ECOSYSTEM TO SNS
Tight Coupling	Integration of RAGE-Interface within the SNS, user does not need to leave the SNS Environment (e.g. user posts a content to the RAGE Ecosystem without leaving the SN-Environment; user remains on the SNS)	Integration of SN-Interface within the RAGE Ecosystem, user doesn't leave the RAGE Environment (e.g. user posts, likes etc. a content without switching to the SNS; user remains on the RAGE Ecosystem)
Loose Coupling	SNFs are related to SNS (links from RAGE to the SNS) User lefts the RAGE Environment and switches to the SNS; user has to complete the action on the SNS, not on the RAGE Ecosystem	SNFs are only related to SNS (link from RAGE to the SNS) User leaves the RAGE Environment and switches to the SNS; user has to complete the action on the SNS, not on the RAGE Ecosystem

5. SNF usage scenarios and design concept

In addition to outlining our SNS integration approach and methodology, Figure 4 displays how the SNF usage scenarios can be integrated into the RAGE Ecosystem itself. RAGE Ecosystem users can visit content and knowledge management support within the RAGE Ecosystem's a Digital Library, Media Archive,

Software Repository, and Learning Management System. Here, users have the opportunity to:

- Rate **(1)**, like **(2),** and Comment **(3)**: these SNFs are e.g. important for the recommendation system to get more useful suggestions.

- Tell a friend **(4)**: users can send links to selected content (or the content itself) through email. Email addresses can be selected either from the RAGE address book or from users' address books which are located in SNEs.
- Share and post **(5)**: Users can share the selected content to one of their favourite SNSs (SNSs) or on the fly to more than one by selecting them from the share button
- 

Users also have the possibility to publish content to a repository (e.g., GitHub's repository) or to cloud storage (e.g., into Dropbox).

- Favourite **(6)**: Users can add content to their favourite lists which facilitates to later, e.g., share/post their entire favourite list to a community.
- Share and post to RAGE Communities **(7)** within the RAGE Ecosystem and also from any other platforms outside the RAGE Ecosystem. A RAGE Share-Button can be released and, e.g., be integrated by developers into other portals, homepages, ecosystems etc. to provide the possibility to Internet Users to share and post their content to the RAGE-Ecosystem.
- RAGE Follow-me **(8)**: RAGE users can follow other users, groups or content in order to keep themselves up-to-date.

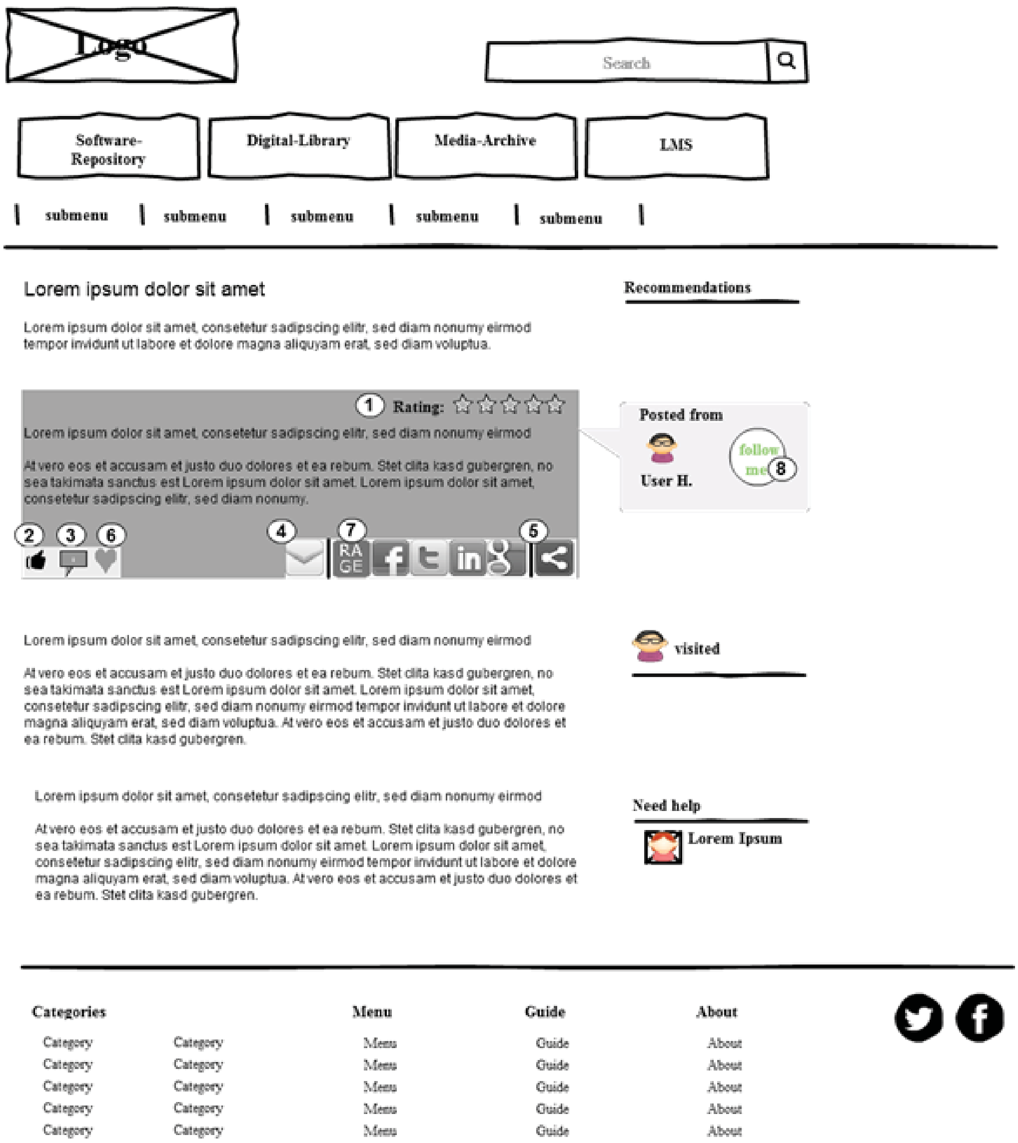

Figure 4: SNF usage scenario in the RAGE ecosystem

6. Conclusion and outlook

In this paper, we have introduced the concept and initial design of the RAGE Ecosystem supporting community-based content and knowledge management. In detail it will support the collection, sharing, access, and re-use of applied gaming research and development assets, resources as well as academic, industry, and end user best practice knowhow. In this way, the RAGE Ecosystem will provide applied gaming communities, and therefore GBL communities, too, an opportunity to interact, share and re-use knowledge as well as communicate and collaborate using the RAGE Ecosystem. Besides this introduction, we have presented how integration between the RAGE Ecosystem and SNSs can be achieved to reduce the fragmentation and to increase the knowledge exchange among applied game communities (such as applied game developer, researchers and players). The RAGE Ecosystem and its SNS and SNF integration are currently under development. In the future, RAGE is aiming at increasing outreach and take-up of the RAGE Ecosystem through further SNS integration and SNF implementation. For example, the SNA and discourse analysis will be used for collecting, analyzing, and presenting data about various patterns of relationships among people, objects and knowledge flows within the RAGE Ecosystem and will provide additional functionality and sophisticated services for end-users, enhancing the emergence of communities. In particular, future developments will focus on identifying collaboration opportunities among individuals and groups, to support matchmaking and collaboration among main stakeholders, and to identify and provide support for innovation opportunities and creativity efforts. In this way, the RAGE project currently anticipates the following additional tools and services as part of its future work:

- The RAGE Diagnostic tool based on various metrics for analyzing the usage of resources, the formation of different users groups, the level of social interactions, etc.,
- the RAGE awareness tool can increase participation of different target groups in the Ecosystem,
- the RAGE Knowledge Mapping tool builds and analyses knowledge maps for all kind of resources available in the Ecosystem.
- the RAGE Professional support tool will support the users by letting them know whom or where to ask for support in different situations,
- the RAGE Community detection tool will use available clustering algorithms (also called ''community detection algorithms'') that automatically identify and locate existing communities, in order to enhance the communication between gaming practitioners,
- the RAGE Ecosystem analysis tool will apply network analysis including many algorithms for identifying the most important, or central in some sense, nodes within a network,
- the RAGE Recommendation may generate value interventions towards stimulating the participation of users. Such interventions include suggesting connections among users, setting up groups, closing the gaps in people's knowledge of other members' expertise and experience, and strengthening the cohesiveness within existing teams. Social media data such as tags, comments, purchasing patterns, and ratings can be used to link related gaming assets and users together into networks,
- the RAGE Social learning tool applies SNA to online learning environments as well, focusing on the structural relationships between all learning objects and users, that support learning communities.

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Learning Object-Oriented Programming With Computer Games: A Game-Based Learning Approach

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Abstract: Using traditional ways to learn object-oriented programming in tertiary education is insufficient due to the new teaching and learning pedagogy. The major purpose of this study is to propose a game-based learning conceptual framework which is suitable for creating games for learning object-oriented programming in the tertiary level. This study presents the outcome from an extensive field study at university level, where computer science degree students learn object-oriented programming with computer games that emphasize game level design, gameplay, and player experience. The proposed game in this study only focuses on the player experience where the player is able to learn object-oriented programming while playing the game without using any coding exercises. Games made for coding practice can be very tedious, making it difficult to motivate students and providing a negative perception for learning programming. In this paper, it describes a game-based learning approach framework which focuses on gameplay and player experience to achieve the learning purpose and retain student motivations.

Keywords: game-based learning, object oriented programming, learning and motivation, gameplay, player experience

1. Introduction

Nowadays, computer games have been adopted as teaching and learning tools in the education field and training field. Computer games often have a negative impact on people because most people treat computer games as an addiction for the child or learner. However, some studies show that through using computer games as teaching and learning tools, the child or learner is able to pick up the skill and knowledge they are supposed to learn from the traditional teaching approach, for example, Counting Game by TopMark. Thus, computer games have great potential to assist teachers and engage learners in a new and challenging way. Basically, the educator's concern is how a computer game can relate to the teaching environment with minimal violation of the learning objective. This is crucial for the game designer to answer. Therefore, effective game design is a significant process for the game designer. The game industry is very wide and consists of great opportunities for businesses. From the research of Mugnai, Jones and Wong, 2002, they found that today's children play an average of 10,000 hours of games (Oblinger, 2004). It is because of this huge popularity that a lot of researchers are helping game developers to explore the possibility of using games as learning and teaching tools (Katie Larsen McClarty, Aline Orr, Peter M. Frey, Robert P. Dolan, Victoria Vassileva, Aaron McVay, 2002). Originally, the first educational computer games have been designed as drill and practice games (Kurt D. Squire, 2008). The format consists of problems or multiple choice questions about the intended topic within the context of an unrelated story. However, this kind of educational game is different from a commercial game. This is because the drill and practice game is only embedded with a basic single goal compared to a commercial game which comes with plenty of goals to achieve. The most common game genres for educational games are simulations and role-playing games (RPGs). Simulation games are suitable for application in an educational context because the participant or the learner is given full control of the gameplay and can react as the hero of the game. Based on this circumstance, the learner will have a simulated environment where they can practice a particular skill or technique. Meanwhile, adventure games are also suitable for application in an educational context. This is because RPGs normally require the learner to act as the character of the game in order to solve a problem or puzzle within a circumstance where the learner can collect the necessary information. However, some of the existing game tools for learning programming, such as Alice (Salim,Hassan, Hamdi, Youssef, Adel, Khattab, 2010), Darwin (Edgar, 1987) and Greenfoot (Kolling, 2008), require students to involve coding exercises, which can reduce the enjoyment for the entire learning process. As a result, students will lose their interest and motivation to learn programming by playing games. The major purpose of this study is to propose a game-based learning conceptual framework which is suitable for creating games for learning object-oriented programming in the tertiary level. In this paper, it describes a game-based learning approach conceptual framework which focuses on gameplay and player experience to achieve the learning purpose and retain student motivations.

2. Literature review

2.1 Computer games in education

All computer games have to deliver a certain level of interaction and communication to the person participating in the gameplay. In order to use computer games as learning and teaching tools, certain questions should be answered, such as how the interface teaches the learner, the storyboard of the game and, the rules of the game (Wong, Yatim. M, Tan, 2014). The most important concern for computer games is how to retain the learner's focus on the gameplay. One of the significant aspects is the user interface (Adcock, Watson, Morrison, Belfore, 2008). This is because without the user-friendly and easy-to-understand interface, learners will grow bored and frustrated and end up leaving the game. The user interface also represents the first impression delivered to the learner about the game. A clear and simple interface will make the learner feel more comfortable. At this stage, the learner will explore the entire game and enjoy it as well. For example, the game *Banjo Kazooie* (Pagulayan, Keeker, Wixon, Romero & Fuller, 2002) requires the player to demonstrate the ability to complete certain important tasks during the first level.

2.2 Internal factors influencing students

There are several factors that influence a student's cognitive engagement while learning programming. Biggs (1987) categorizes these factors into student-based factors, teaching-based factors, and the system. Meanwhile, Helme and Clarke (2001) groups the factors affecting cognitive engagement as the individual, the environment, and the learning task. For the individual, Helme and Clarke (2001) state that "students need to have both the will (motivation) and skill (capability) to be successful learners. It is the experience of teachers that students who are motivated to learn and who think carefully about what they are learning develop deeper understanding of the material being covered." (p136) Helme and Clarke (2001) also state that "the individual brings to the learning situation numerous characteristics that influence their cognitive engagement. These include: skills, knowledge, dispositions, aspirations, expectations, perceptions, needs, values and goals" (pg138). According to one multi-national and multi-institutional study that investigated the programming competency of first year tertiary students, they found that "many students do not know how to program at the conclusion of their introductory courses" (McCraker et al., 2001). Many researchers showed that there are several factors influencing a student's ability to learn programming successfully in their first year of study. The success factors are a student's background in mathematics and science (Byrne & Lyons, 2001; Willson 2001); (Bergin & Reily, 2005), learning style and problem solving skills (Beaubouef, Lucas, & Howatt, 2001); (Goold & Rimmer, 2000); (Haden, 2006), prior academic experiences, self-perception, and specific cognitive skills (Bergain & Reilly, 2005). For this study, the focus is on proposing a computer game, with no programming exercises, for students to learn object-oriented programming. Thus, self-motivation is very important in this context. Students need to build up their interest and remove the barrier of learning programming in order for them to pick up the necessary programming concepts. Learning programming is different from learning a particular programming language. If students are able to understand the concept of the object-oriented programming paradigm, they can code in any object-oriented programming language.

2.3 Learning difficulties in programming courses in Malaysia

According to Moser (1997), programming is a multi-layer skill which can be boring, intimidating, and unrelated to a student's day-to-day experience where they only learn in a single context. Most undergraduate students in Malaysia do not have any programming experience before they enrol into a degree programme. Most of them are learning programming in a single context, meaning only one programming language. This situation causes the student to have negative programming habits which affect their adaptability to learn other programming languages. Subsequently, most students begin to think that programming is difficult to learn and apply. A study about learning difficulties in programming courses for undergraduate students was conducted in Malaysia, involving 185 undergraduate respondents (Tan, Ting, Ling, 2009). According to the study, most respondents were low in confidence when it comes to their programming skills. According to the study, the difficulties faced by undergraduate students were designing a program to solve certain tasks, dividing functionality into procedures, learning the programming language syntax, finding bugs from their own program, and understanding the basic concepts of programming procedure. It showed that the current method of teaching programming is inadequate. The study also showed most of the respondents agreed that learning by example, exercises, and interactive visualizations were the most appropriate materials for learning programming. The overall response for using games to learn programming was positive. In order to address the problems mentioned, a proper game-based approach model is required. With the appropriate model, an appropriate game can be developed for students to learn object-oriented programming effectively.

2.4 Learning theories and approaches

Nowadays, students are increasingly audio-visual-driven learners with diverse learning styles. While educators have adopted various methods to cater to each new generation of students' needs to make learning less painful, such efforts do not yield the same effect as playing computer games where game players are willing to learn as they play. Computer games present an engaging experience within the virtual world where most participants are willing to spend hours being immersed and amused. Such behaviors are the result of active participation within the gameplay and interactive storytelling that motivate game players to engage in activities within the game world. Several proposals on designing educational games from different perspectives have been created such as Malone's thoughts (Malone, 1980), Prensky's digital game-based learning book (Prensky ,2005), Pivec's six steps to create educational games (Pivec ,2003), Buchanan's approach (Buchanan ,1987), Paras's integrated model (Paras ,2005), Denis and Jouvelot's motivation-driven educational game design principle (Denis and Jouvelot, 2011), and more. The early thoughts of Malone showed that the guideline for developing educational games was by identifying some essential characteristics such as challenges, fantasy, and curiosity. While in Prensky's book, Digital Game-Based Learning, it showed the types of learning and possible game styles for educational games. Next, is Pivec's six steps of educational game design. They are: determine the pedagogical approach, situate the task in a model world, elaborate the details, incorporate underlying pedagogical support, map learning activities to interface actions, and map learning concepts to interface objects. Buchanan (Buchanan 1978) suggested a parallel iterative approach which combines iterative game design with an interactive educational approach. Paras proposed Csikszentmihalyi's 'Flow theory' (Csikszentmihalyi, 2003) as a communication channel for understanding and implementing motivation through play to construct an integrated model for educational games. Denis and Jouvelot's (Denis and Jouvelot ,2011) motivation-driven educational game design principles concerned several perspectives such as reify values into rules, give power, tune usability, derail the gameplay, and favor communication centred on Deci and Ryan's 'Self Determination Theory' (Ryan, Deci, 2000).

3. Research method

3.1 Research approach

The proposed framework development process is adopting Action Research approach. This is because it involves researchers working on a specific problem with a subject and involves a carefully documented and monitored study of an attempt by the researchers to actively solve a problem and/or change a situation of any related environment. The reason to adopt action research for this study is because this approach provides a set of principles which guides the researcher to carry out the research in an effective way. The set of principles includes reflexive critique, dialectical critique, collaborative resource, risk, plural structure, and theory, practice and transformation.

3.2 Research framework

Table 1: Proposed research framework

Hypothesis	- 3 groups of Bachelor of Game Development students (from different semester)
Develop the Game Based Learning framework model	- Detailed action research model and Instructional Design Methodology - GOM (Game Object Model),POM (Persona Outlining Model), GAM (Game Achievement Model)
Construct game design, game interaction, game world design, storyline, game mechanics, topic covered	- Create the complete storyboard for the game., Design the game world environment, Design game character such as hero and NPC and Design the interface of the game
	- Several topics of object-oriented programming subject will include in the game such as: Class and object, Variable declaration, Control structure and function, Inheritance, Polymorphism. The covered topic will incorporate to the different level in the game.
	- Instructional game design methodology - Bloom taxonomy, Operant conditioning theory, Maslow's Hierarchy of needs theory, Constructivist theory, Conditions of learning theory
	- Current first year students who attending the Object-oriented programming courses will use the software tool to determine the outcome of the research - Pilot testing will incorporate into the study to make sure the research is on the right track.

3.3 Research methodology

In order to construct the proposed conceptual framework, a new approach called Instructional Game Design Methodology (shown in the below figure) (Tang, Hanneghan, 2014) have been referenced. This design methodology focused on the instructional learning design style. According to this methodology, in the beginning stage, game intros should gain the attention of the learner and play the role to inform the player. Besides that, game tutorials are given to help the player familiarize themselves with the gameplay. In the game tutorial stage, it is necessary to present stimulating material to the player and provide the necessary guidance. Moreover, in the game tutorial stage, the gameplay environment can include abstract conceptualization, active experimentation, reflective observation, and concrete experience to form a challenges cycle which involves synthesis, elicit performance, and feedback. The following stage for the player is entering the game level to further gameplay. This methodology is suitable for developing educational games. However, in order to develop a computer game for learning object-oriented programming in tertiary education, several theories need to be included in the methodology mentioned.

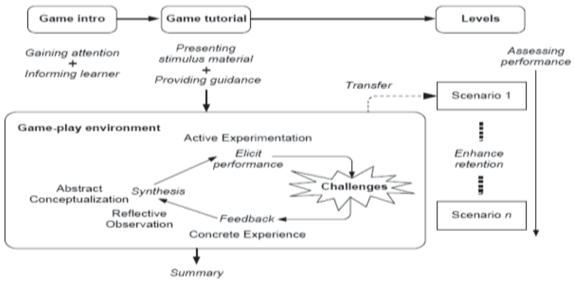

Figure 1: Instructional game design methodology (Tang, Hanneghan, 2014)

The relevant theories needed are Bloom Taxonomy, Operant Conditioning Theory, Hierarchy of Needs Theory, Constructivist Theory, and Conditions of Learning Theory. Bloom Taxonomy Theory (Forehand, 2010) identifies six levels within the cognitive domain from simple recall or recognition of facts as the lowest level through increasingly more complex and abstract mental levels as the highest level which is classified as evaluation. The six levels of Bloom Taxonomy are knowledge, understanding, application, analysis, synthesis, and evaluation. It needs to be included in this proposed model because it takes into consideration the learning process. Bloom Taxonomy provides six levels, from easy to difficult, to incorporate with the learning process where relevant to the game balancing issues. Game balancing plays a significant role in retaining the student's interest. Thus, it will be required when designing the gameplay learning environment. The level difficulty should be progressively increased. Bloom Taxonomy playing significant role in term of providing the progressive learning in the proposed framework. Learning object-oriented programming required to learn from basic to comprehensive level. For example, the proposed framework required the game designer to consider the learning path when designing the level. It is necessary to ensure each level is connected with continuous learning path with different level of difficulty. With this, it can construct the learning environment that able to help the student to learn the content from the game effectively.

As for the Operant Conditioning Theory, it focuses on the idea that learning is a function of change in overt behaviour. Changes in behaviour are the outcome of an individual response to certain events that occur in the individual environment similar to the gameplay. The player will find that they are the hero within the game. Therefore, the reactions or the changes from the learner/player are directly reflected in the game world. This theory will be applied to enhance retention for the students. Compare to the traditional teaching approach, it is very challenging for the lecturer or teacher to retain the student attention. Students are very easy distracted by the environment. Therefore, the proposed framework is required the game designer to take consideration of this theory when designing the game world environment. The game world should provide adequate and appropriate changes in the game world to regain the player attention as well as refreshing the player mind to continue to learn the subsequence content. For example, the proposed game will be changing the game world for each level.

Maslow's Hierarchy of Needs (Gawel, 1997) is a theory in psychology contends that as humans meetbasic needs, they will continue to look for higher needs for their satisfaction. This theory proposes five levels of need such as: Level 1, Physiological; Level 2, Safety; Level 3, Love/Belonging; Level 4, Status; and Level 5, Self-Actualization. The four lower levels are categorized as deficiency needs associated with physiological needs, while the top level is called growth needs associated with psychological needs. According this theory, even when the deficiency needs have been met, our needs will continually shape our behavior. In other words, high need will occur when the lower level needs have been achieved. It is necessary to include this theory when developing the proposed game. It is because Maslow's Hierarchy can apply to game because, it can make the simulations feel more realistic when needs are part of the player's responsibility, artificial intelligences feel more human when they exhibit these need, players feel more frightened when needs lower in this scale are threatened and complex conflict and choices can be set up when players have to face the tension between needs. Besides that, this theory is also playing significant role in character development in the game. In order to motivate the student, it is necessary to make the student got the ownership of the game avatar with the desire to learn and complete the game quests. Thus, by studying this theory, the level design of the game can be based on the needs of the student. The proposed game should take into consideration the student's needs in order to help them achieve their learning objective. If students could achieve or complete a certain level, it will raise their confidence and allow them to plan for higher needs and to learn more complicated skills. For example, in the proposed game, each quest will be design based on the different level of needs of the character.

Constructivist Theory (Richardson, 1997) proposes learning as an active process in which learners construct new ideas or concepts based upon their current/past knowledge. According to this theory, the learner is allowed to select and transform information, construct hypotheses, and make decisions relying on a cognitive structure. The meaning of cognitive structure is a schema or mental model provided to produce meaning and organization to experiences and allow the individual to get future information. It is necessary to include this theory to the proposed model because it will develop a game which allows the learner to have the freedom to think about the information obtained from the game world. This will help the learner to easily acquire the knowledge or skill. For example, informative dialog sections will be included in the game world. The purpose of doing this is to make sure the learner have enough informative knowledge to carry on with the gameplay. This theory also states that a theory of instruction should address four major aspects: (1) predisposition towards learning, (2) the ways in which a body of knowledge can be structured so that it can be readily grasped by the learner, (3) the most effective sequences in which to present the material, and (4) the nature and pacing of rewards and punishments. Students are learning the object-oriented programming concept via the conversations between the game hero and the non-player character. Throughout the conversation, the proposed learning content will be presented to the student. The narrative system of the proposed game is referring to this theory, which all conversation between actor and non-playing characters are information and learning content sharing.

The Conditions of Learning Theory (Gagne, 1985) assures that there are several different types of learning. This is because different types of learning require different types of instruction. According to this theory, there are five major categories of learning: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. This learning theory also suggests that learning tasks for intellectual skills can be organized in a hierarchy according to the complexity of several aspects such as stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem solving. As part of the proposed model, the active experimentation requires students to synthesize the game condition based on the level designed, for example, stimulus recognition (in quest 2, recognition of keywords), response generation (in quest 5, array manipulation), procedure following (quest 3, selection structure), use of terminology (in quest 1, keyword recognition), concept formation (in quest 3, looping structure) and problem solving (in quest 7, methods).

3.4 Proposed conceptual framework

In order to prove the proposed conceptual framework is suitable for this research, structure questionnaire has been conducted with subject experts (SE) and game designers (GD) whose experience in developing education games. There are 10 questions included in this interview, both subject expects and game designers are required to play the propose game before answer the questionnaire. The subject experts are responsible to evaluate the content or topics that cover in the game are relevant to the game objectives. The game designers are responsible to evaluate the game-play and storyline.

Table 2: Percentage of game designer and subject expert views

Questions For Subject Expert	Agreed (%)	Neutral (%)	Not Agreed (%)	Questions For Game Designer	Agreed (%)	Neutral (%)	Not Agreed (%)
1	66.66	33.34	0.0	1	66.66	33.34	0.0
2	66.66	33.34	0.0	2	66.66	16.67	16.67
3	66.66	0.0	33.34	3	66.66	33.34	0.0
4	66.66	33.34	0.0	4	66.66	16.67	16.67
5	66.66	0.0	33.34	5	83.33	16.67	0.0
6	66.66	33.34	0.0	6	83.33	16.67	0.0
7	33.34	33.33	33.33	7	66.66	16.67	16.67
8	33.33	33.33	33.34	8	49.99	16.67	33.34
9	33.33	33.33	33.34	9	66.66	0.0	33.34
10	66.66	33.34	0.0	10	66.66	16.67	16.67

The proposed framework for this research shown in Figure 2.0 with includes all the necessary learning theories.

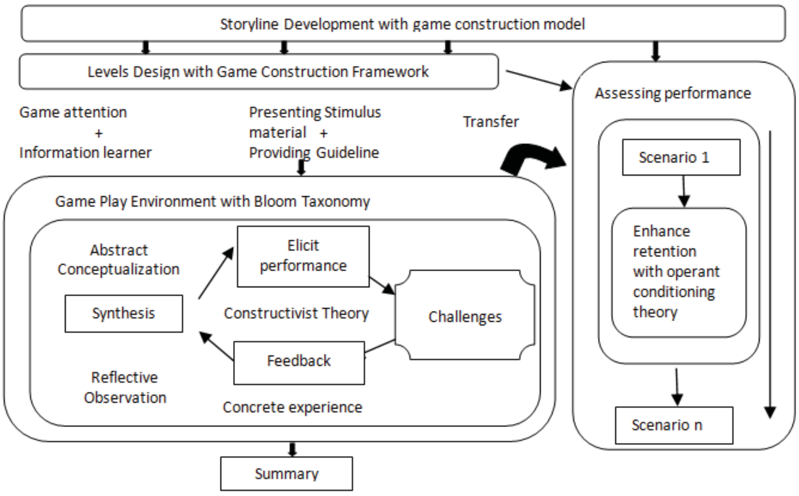

Figure 2: Proposed game-based learning design approach conceptual model

4. Proposed game

The game prototype for this research is built based on the proposed conceptual framework. Basically the conceptual model development begins with designing the level of the game based on the Maslow's hierarchy. Thus, analysis of user and task are required to be conducted. Understand the user need will be the significant task. It is necessary to understand the target user requirements in order to design the level precisely and accurately. To collect the user requirements, some information collecting techniques such as survey and questionnaire will be used. Questionnaire surveys were conducted in this study. Students from Bachelor of Game Development, i.e. offered by a private university in Malaysia had participated in this study. After obtaining the user requirements, the next stage was to define quest which align with the learning content from syllabus in each level. The final stage of this approach was to commence development of the prototype and testing the interface design. A well design testing plan was applied to the prototype to evaluate the overall functions. According to the Action Research approach, if any problem was discovered during the testing process, this approach would allow a revision of the previous stage in order to solve the problem.

Besides that, Amory and Seagram game construction model also included in the proposed conceptual framework. This model includes three sub models; there are GOM (Game Object Model), POM (Persona Outlining Model) and GAM (Game Achievement Model).

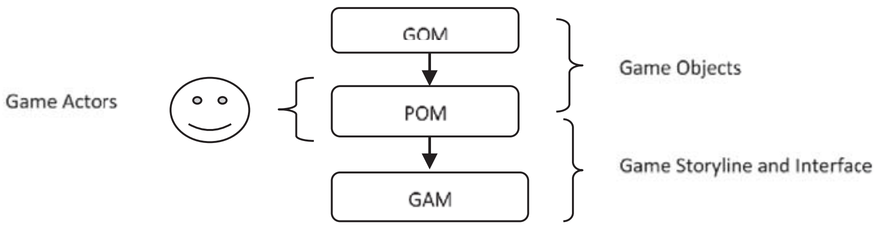

Figure 3: Game construction frameworks

This model focuses on the significance of the storyline in the game being developed.

The purpose of using GOM is to help game designers to define the learning objectives and the required game components for the storyline. The identification of the objectives and components accelerated the game design, particularly the entire game design architecture. Meanwhile, POM is used to help game designers to organize who are the actors in their game and what role the actors would play in the game story. The actor selection process is very important to the educational game because actors are those who interact directly with players or learners. Therefore the learning expectation and requirements are significant for game designers. For the proposed study, the subject expert (university lecturer) and computer science students were selected as actors for the research. The reason for selecting them is because the proposed study required their input and feedback to design the game accordingly. GAM is the last layer of this model. This layer defines the interface and the storyline of the game. The storyline of the game is significant because it keeps the user or learner playing in the game, i.e. to find out what happens next. A good storyline or background story is able to help designer to identify the characters involved in the game. The storyline is a about character who needs to solve all the puzzles in different levels and collect required components to complete the quest. The overall storyline design is based on the above mentioned GAM model guideline.

4.1 Game genre

As mention above, role-playing game (RPG) is one of the common game genres for educational games (Wong, Yatim. M, Tan, 2014). Thus, it has been proposed to include RPGs in this study. This is because RPGs allow the participant to adapt to the game world. The participant will act as the hero of the game. In order to relate to the research, the participant (student) will act as a robot engineer. The task of the robot engineer is to build a completely functional 3D-model robot which can react to different environments in the game world.

4.2 Storyline

Ztech de Object-Oriented is a computer game that guides users to learn object-oriented programming in an easy and relaxing environment. Players or users will play along with the flow of the program step-by-step as they learn to grow their character (Ztech). To enhance the learning process, this game possesses an attractive storyline, pleasant game environment, nice and suitable sound effects, elegant character design, and appealing animations. When the game starts, the character will have the navigation system that allows it to travel around the game map. In order to become stronger and more powerful, it has to fight with enemies who are terrorists. Some NPCs will help the character by providing it with missions. When the character finishes the missions, it can earn rewards either by increasing experience or by obtaining new equipment to improve current abilities. While the users are having fun with the game, they are actually learning object-oriented knowledge. Ztech de Object-Oriented is a stand-alone game in which each player will play and learn in his or her own application. The game guides users to understand the concept of object-oriented programming. The gaming part aims to increase and foster the users' interest in learning the knowledge. The game provides users with all the basic object-oriented concepts like encapsulation, inheritance, and polymorphism. In addition, the game includes some basic programming concepts which could improve the users' understanding. Ten mini puzzle games are featured with basic programming knowledge through five levels in the game. With these features, Ztech de Object-Oriented could be a catalyst to smoothen the path of learning object-oriented concepts.

This game consists of five levels. First, the basic knowledge of object-oriented approach is introduced to players. They should pass through the first level after going through the objects and classes test. In level two, players are guided to learn about the control statement like if else and switch case as well as the structure of the method declaration. In the third level, the players are led to learn about the array and three types of looping statements. Quests are assigned to the players to ensure that they comprehend the concepts behind the knowledge. By completing the quests, players can proceed to the next level. In the fourth level, players start to learn about the main principles of object-oriented programming. They are exposed to the concept of encapsulation and inheritance. Examples are provided to bolster their understanding. At the last level, the game guides the players to learn about polymorphism principle. The game ends when players defeat the last boss, called Virus. From time to time, players are rewarded for their enthusiasm, in which they are encouraged to continue to learn new knowledge and skills.

5. Finding, implication and result

For the pilot testing, the degree modules named Object Oriented Programming have been selected. Total of 40 students from Bachelor of Game Developments (Honours) programme have been participating in this research. The subject mentioned offered in Year 1 semester 3. For the selected modules best fit to this research because the content and the topic covered focus on the fundamental of object oriented programming such as variable declaration, memory allocation, object and classes, encapsulation, inheritance and polymorphism. The proposed game was installed prior class, and students are required to play the proposed game in class. Student will play the game according the game flow (levels) and complete the quests for each level. As mentioned, each quest is equip with learning objective which refer to the subject syllabus. Students are allowed to save their progress and continue during next class. At the end of the semester, a set of questionnaire that consists of 10 questions was giving to all the participated students. They are required to complete the questionnaire. The purpose of the questionnaire serves as a platform for the student to comment and provide constructive opinions about the game and evaluate the effectiveness of the proposed game serve as a learning tool for learning object oriented programming.

Upon completing the pilot testing, the feedback and suggestion obtained will be take consideration for further development. In order to further research on the proposed study, several research areas need to be improved such as sampling for hypothesis sampling, game quests and etc. According to the pilot testing, only 40 students from one university are participated. It is necessary to include more students from different institution to be involved to increase the sampling size. In order to obtain the validity of the proposed conceptual framework suitable for creating games for learning object-oriented programming in the tertiary level, more subject experts and game designers are necessary to participate in the research. Besides that, the in-game story and game quests need to refine accordingly with appropriate game mechanic and gameplay.

6. Conclusion

Learning object-oriented programming paradigm can be difficult and challenging for novices, especially first-year degree students who do not have any prior programming experience. The traditional learning and teaching methods are insufficient to support the learners or students. A game-based learning approach can be an efficient way for the students to learn object-oriented programming. Thus, this study proposes a game-based learning design approach conceptual model as a guideline to develop computer games for students to learn object-oriented programming paradigm. In the proposed conceptual model, several relevant theories are included to ensure the entire learning process is motivating and easy to learn. In the proposed game that is developed according to the proposed conceptual model, the game divides the learning content into several levels and quests. Students are required to communicate with the non-player character for learning purposes and to complete the quests to proceed to the next level. Each quest adopts different gameplay mechanics to suit the learning objective. It is important to bear in mind that play is one of the most effective ways for learners to acquire whatever knowledge they require. Computer games can be an engaging learning medium for the teaching and learning process. They can guide the learners step-by-step to achieve learning objectives based on their learned skills and their preferences. Thus, future researchers will further evaluate the proposed model and game on how to support novices to learn object-oriented programming paradigm effectively.

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Non Academic Paper

Gamification in Higher Education: How we Changed Roles

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Abstract: Squire claims that a good game encourages good learning that "enables us to become knowledge producers [which] gives us robust ideas to think with, and propels us toward participation in social practices" (2013). Inspired and intrigued by the possibilities of using game environments as learning spaces, which can lead to social changes (McGonigal, 2011), the instructional designers at the University of British Columbia ventured into the "unknown" and transformed a "traditional" online course on adult education into a role-playing game. This paper explores the notion of gamification in a higher education setting, what it means in terms of instructors' teaching practice, and how it changes student experience. The paper describes how game elements were incorporated into a course. The goals were to 1) engage students by creating a responsive feedback system, and 2) empower students by allowing them to customize the game experience based on their learning style and interest in the topics. The game space designed for the students enabled them to explore and try different things, and also realize that their work mattered. The paper focuses on the process and challenges of "gamifying" academic content and outlines the elements that make the game successful and sustainable. The designers purposefully avoided creating a virtual world or environment similar to an MMORPG, or investing a significant amount of funding and time into creating a space where only experienced gamers would feel comfortable. The new gamified version of the course needed to be low-tech, but enable high-social learning. The goal was to increase student engagement in the course, especially their interaction with one another, without technology getting in the way of their learning. The course was therefore taken out of the structured and formal LMS and transferred into the more flexible and social WordPress environment. The students took on two roles: 1) the role of reporters who were required to write about adult education issues and respond to different tasks set out by their Editor in Chief, and 2) the role of readers who responded to the written articles. Together, they were contributing and building the newspaper "Adult Educator Weekly". The design of the course enabled students to receive timely feedback from their peers, which made the students feel their writing was relevant and purposeful. Based on the students' feedback, the gamification of the course contributed to their increased interest in the topics, engagement with the course, and understanding of the issues from different perspectives.

Keywords: gamification, higher education, role-playing, engagement, empowering

1. Theoretical background

There have been many definitions and theories of game and play, from Huizinga, a Dutch cultural historian who connected games to culture in 1938, to current game theorists, like Sutton-Smith (1997), Salen and Zimmerman (2004) or James Paul Gee (2005). Deriving from those definitions, an American game designer, Jane McGonigal (2011), identifies four broadly accepted elements of game: a clearly defined goal, rules, feedback mechanism and voluntary participation. Having a defined goal with desirable outcomes, which are what the player hopes to achieve by playing the game, provides a sense of purpose for the player. Rules are to limit how she can achieve the goal. This confinement makes the player rely on her creativity and strategic thinking in exploring the environment to produce the desired result. While the person is trying to achieve the goal within the limitations of the rules by testing different strategies, the feedback tells the person what worked and what didn't work. Finally, players in the game knowingly and willingly participate in it, accepting the goals, the rules and the guidance of the feedback.

The term "gamification" means applying game mechanics and game design techniques to non-game environments in order to help people achieve their goals. Gamification has become popular in the last decade. It has been used by companies (e.g. airline companies, retailers, etc.) to attract customers and it has gained traction in education. Kapp (2012) outlines the design process of incorporating elements of a game into teaching instruction. He discerns two types of gamification: a gamification of content, and structural gamification.

Gamification of content means altering the content to make it more "game-like"—for instance, overlaying the content with a storyline and characters, or incorporating music, sound, or graphics into the game. Structural gamification, on the other hand, is applying game elements to guide learners through the content without changing the content. Structural and content gamification can complement each other quite well and be used together to create an engaging experience, which is what the instructional designers did in the redesign of the UBC course.

While McGonigal advocates for games in everyday life to "make us better, and change the world" (2011), Gee (2013) explores the principles embedded in game design that can help us improve educational practice. He notes, for example, the importance of immediacy in the feedback system. The quick feedback allows the players to see the effects of changing one aspect of the strategy. This either motivates them to continuously modify different elements based on the results until they achieve the goal, or rewards them with instant gratification when they succeed right away. Gee claims that by applying this principle in an academic setting, the learning experience becomes more engaging for the students. Linking assignments more closely with various types of feedback will enable students to recognize where improvements can be made and implement them right away.

1.1 Why does gamification matter in education?

Dr. Kurt Squire (2013), from Wisconsin University, describes an experiment in which he studied the effects of gamified learning on students' test scores. Squire hypothesizes that gamified learning leverages the concept of Preparation for Future Learning (PFL), where meaningful and engaging learning experiences better prepare students to learn additional concepts (Bransford & Schwartz, 1999). That is, well designed game play can engage students with a topic on a deeper level by driving them to internalize the material, and thus to understand it better. This type of learning prepares the students to absorb new relevant content better than if they had not had this deep experience with the subject matter.

In Squire's control experiment study, the variable is whether students have played the game *Citizen Science*, and how this impacts test scores. In the game, the player is a young adult who becomes concerned about the health of a local lake threatened by eutrophication, and the goal of the game is to restore the lake (Games Learning Society, 2013).

On Day 1, both groups took a pre-test. On Day 2, students in the control group had a "traditional" experience where they read about the lake and lake beautification. The information was derived from the game and presented in a narrative way with text and graphs. Meanwhile, the experimental group played the game. Both groups were asked to take a test immediately after they had finished reading the packet or playing the game. On Day 3, the groups were exposed to new information in a reversed manner, where the control group played the game and the experimental group read the packet, then both groups were tested again (Figure 1: Structure of the PFL experiment).

Preparation for future learning

	Day 1	Day 2	Day 2	Day 3	Day 3
Control	Pre-Test	Packet	Mid-test	Game	Post-Test
Experiment	Pre-Test	Game	Mid-test	Packet	Post-Test

Figure 1: Structure of the PFL experiment

Squire observed that PFL indeed seemed to have been a factor (Figure 2: PFL effect on test results). The experimental group performed better with each new test, compared to the control group, which performed relatively the same in all three tests. Furthermore, through naturalistic observation, Squire noticed that students in the control group were simply not very interested in the material when reading the package compared to more enthusiastic students in the experimental group playing the game.

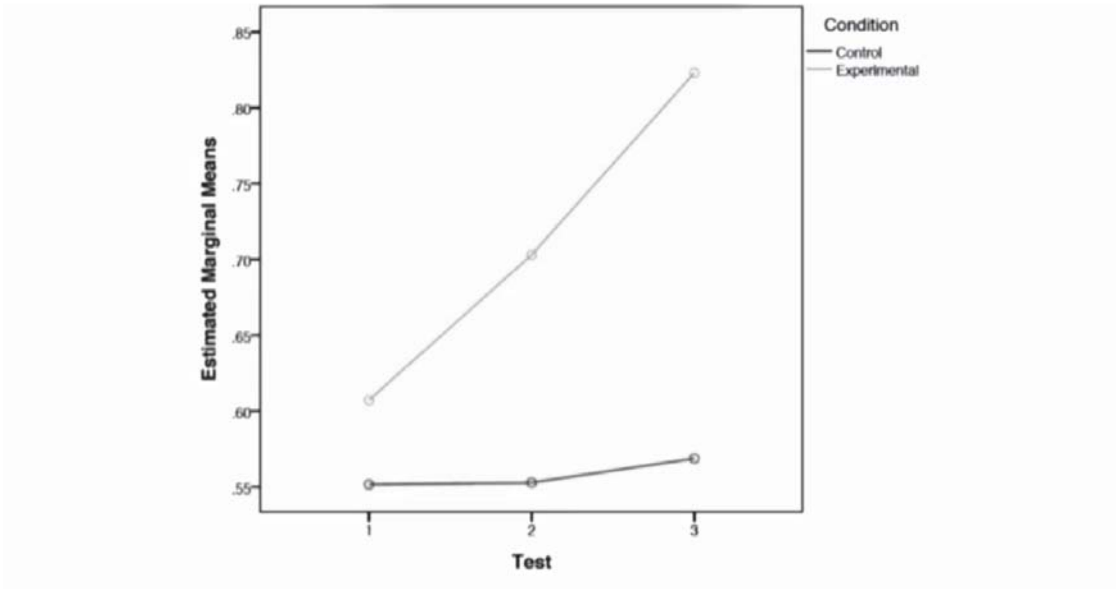

Figure 2: PFL effect on test results

2. Context

Inspired by contemporary research on games in education, the instructional designers from the Faculty of Education at the University of British Columbia (UBC) proposed to gamify an existing online fourth-year undergraduate course on adult education. The model for this transformation was Jane McGonigal's online game *Urgent Evoke, a Crash Course in Changing the World*. *Urgent Evoke* was an alternate reality game that used the real world as the platform, and its storyline was based on real-life problems. In *Urgent Evoke*, players earned points by taking on the role of agents. They completed a mission and quests every week for ten weeks by taking part in real-life activities. For example, players could choose to participate in a mission called "Food Security" and gain points by completing tasks such as building a community garden or helping a neighbour set up a backyard garden. Between March and May 2010, over 19,000 people from over 150 countries played this game, and completed thousands of tasks (Gaible & Dabla, 2010). This means that a game has the power to motivate impactful positive actions in the real world and encourage people to combat serious problems.

The designers were curious to see if adding this extra layer of gamified content and structure would change student engagement in and perception of the course. They wanted to create a "good" game that would "provide… possibility spaces in which we get good at doing new kinds of things and become new kinds of people" (Squire, 2013) and encourage good learning that "enables us to become knowledge producers [which] gives us robust ideas to think with and propels us toward participation in social practices".

3. Process

The designers first identified a successful game model (*Urgent Evoke*). Next, they established an overarching goal, which was to foster good learning through a game. Then the planning and designing process began. At that point, there was no clear format for the gamified course, nor was there a chosen hosting platform, but three critical criteria were identified for the gamified course to fulfil. It needed to:

- empower and engage students
- be easy to play
- and be sustainable

The next step was to select a course. A three-credit undergraduate course entitled *Overview to Adult Education* was a good fit for a number of reasons. It was already structured similarly to *Urgent Evoke*. The duration of the course was 13 weeks, but the students had ten assignments to complete in 10 weeks. They needed to respond to a variety of topics in writing, either by researching them, or by taking an action and reporting on that action. The modular format seemed suitable to translate into distinct game missions.

In addition, the students registered in this course were usually from various disciplines, ranging from nursing to business, with diverse academic backgrounds and life experiences. This often meant a lively discussion with a multitude of perspectives, which was an excellent basis for good interaction and an enjoyable game environment. Another crucial element to get the project off the ground was the eagerness of the instructor to try the gamified format. In this case, she was also very experienced in incorporating role-playing into her teaching.

Since there was no expertise in the course development team, a graduate student game designer was hired to assist with building the game space. The consultations and brainstorming lasted for a few weeks, with continual reference to the identified three criteria throughout. The final result was a fictional newspaper called *Adult Educator Weekly*.

3.1 Adult educator weekly (AEW)

Students took on the dual roles of a reporter and a reader in *Adult Educator Weekly.* As reporters, they had to choose to report on three out of ten topics. The "journal articles" were made public and read by everyone in the class. As readers, the students reviewed the articles and posted their comments. They also cast their votes for the best written article of the week. At the end of the course, the articles with the highest number of votes were published in the final edition of the newspaper. The instructor took the role of an editor in chief who gave the reporters their weekly assignments.

4. Meeting the criteria

4.1 Empowering and engaging students

Gee (2013) outlined 13 learning principles that games use to engage people. The guiding principle is to empower the learners; when they choose what to learn, they have control over their learning and they feel what they do matters. In the course, this was achieved by allowing the students to choose 3 out of the 10 possible assignments. They were able to interact with topics that they had deeper personal interest in, or that were more related to their work. The role-playing aspect of the course transferred the students into a different reality. Taking on a different identity—being journalists—gave students the flexibility to write in a more conversational tone, and move away from a traditional academic writing style, which was a requirement of the original course. At the same time, the students were still accountable for the information they provided, so the rigorous research component was still present, as were professionalism and expertise. Having their peers as an attentive audience, as opposed to submitting an assignment only to the instructor, increased their personal responsibility towards the public for which they were writing.

The students were also given control over the design of their own grading. Each student decided the relative weight of each assignment and where he wanted to put the most effort. Each learning activity was worth between 15-30% of the final grade, and the student could distribute the weight of each assignment as he wished, as long as all the assignments added up to 100%. The assignments varied in type, ranging from writing an article for the newspaper as a journalist, to responding to the articles as a reader, to doing a final presentation. This meant that students who preferred to create original work could place a higher percentage on the assignment that required them to write a story, and a lower percentage on providing reader feedback. Students were able to re-negotiate the weightings up until the assignment was submitted. This flexibility in the grading system was powerful, because it gave the students the key to designing their own version of success in the course. The more effort they decided to invest in the coursework, the more they had to gain. Because of the clear distribution of weight, it was very easy for each student to know exactly where he stood at any point of time in the course.

Another element that contributed to student awareness of progress was the immediate feedback that they received daily, either from the instructor/editor in chief, or from readers/classmates. Juul (2008) and Bogost (2007) talk about the compelling impact of immediate feedback. Games with a well-designed feedback system encourage the player to use different approaches to solve the problem, leading to final mastery even after numerous trials and errors. A simple game, such as Tetris, has a very responsive feedback system. As you try different ways to solve the problem (make the falling blocks disappear), you get instantaneous feedback through multiple channels on how well you are doing: from the points you are racking up, from the visual feedback (lines getting higher or disappearing), and from the sound (lines crumpling, when you do particularly well). These simultaneous types of feedback may be one of the reasons why Tetris is so engaging to play. Through trying different ways to solve the problem based on the feedback, the player becomes better at solving the problem. Once the problem is solved, she is presented with a new problem, and the cycle continues.

Similar to Tetris, by sharing the assignments with the entire class, and waiting for classmates to respond to written articles, the journalist was in constant expectation, and reception of, feedback. As the readers required time to digest the information and compose a response, the feedback loop could be very long, and not as immediate. In some cases, the feedback to the articles was not in abundance. To compliment the feedback that represented a deeper analysis, but was occasionally low in frequency, a voting system was added: not everyone could write a critical comment, but everyone was able to cast one vote per story. To increase the motivation for writing a good article, the article with the most overall votes in a week was published as the featured article at the end of the course.

4.2 Easy to play

Students needed to be comfortable with the platform right away, so instead of a robust and complex Learning Management System, the designers decided to use WordPress. The blog format made the learning environment less formal, was easier to customize to look like a newspaper, had a gentler learning curve, and was accessible on mobile devices. Since the course was a university credit course and had a very defined time frame, the students needed to understand the rules of the game immediately. The designers didn't want students to struggle with learning how to navigate a virtual gaming environment, such as Second Life, for example, or to spend hours creating an avatar. A blog was an ideal platform, as many students were already familiar with it, and they felt comfortable working in it. The blog also allowed students to interact with the content and each other seamlessly and instantaneously.

4.3 Sustainability

The project was initiated without a special grant, but small amount of money was approved from the unit's research and development budget. It started as an innovative pilot experiment with the idea to make the course delivery sustainable after the first few offerings, if proven successful. For the course to be sustainable, the following needed to be fulfilled:

- The platform needed to have good interface with no need for extra graphic design, as there was no funding for it.
- The instructor needed to be able to update the content easily as new topics came up, without re-design or special modifications

WordPress is very user friendly and does not require any programming knowledge to update a page or create a post. The platform also makes it relatively easy to copy an instance of the game forward for each new term. UBC has its own instance of WordPress installed on its server, and a team of programmers who can create customized plug-ins (such as the voting system mentioned earlier). This team offers its services across campus to all Faculties, and provides support in customization. The instructional designer provided some initial training for the instructor until she felt comfortable in the environment, and ongoing support proved unnecessary.

5. Results

In 2014, after the gamified course had been offered seven times (with around 25 students in each class), the instructional designers interviewed the instructor who taught all 7 classes and one of the students who took the course.

5.1 Instructor's perspective

The instructor found the most rewarding aspect of the course to be the student-generated critical dialogues, which were fostered by the responsive feedback system. Publishing the articles enabled multiple readers to provide comments which gave timely feedback to the journalists. In addition, when the journalist's article was posted, she could see how many people were engaged in the discussion and "[seeing] there's a response ma[de] it very dynamic and I think that that is really engaging and motivating for the students" (Instructor 2014, per. comm., 14 January).

> *[T]he dialogue that I see everybody creating, sort of as a learning community, is one of the most rewarding aspects of this course and this gamified environment (Instructor 2014, per. comm., 14 January).*

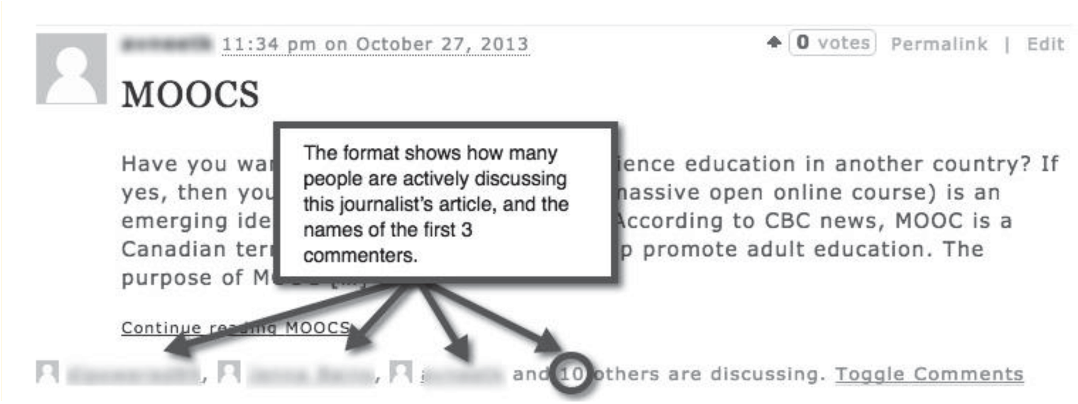

Figure 3: Comments and discussions in the blog

Furthermore, the instructor indicated that the blog format which showed all the comments related to the article on the same page (Figure 3: Comments and discussions in the blog), was more accessible and user friendly than the traditional discussion forum in a Learning Management System. As a result of this responsive and engaging feedback system, "many of [the students] [did] more than the minimum required [posts] because they [were] so engaged with each other" (Instructor 2014, per. comm., 14 January), which further enhanced the exchange of ideas.

Another observation from the instructor was that the gamified flexible learning path proved to be challenging for some students at the beginning. Those were the ones who wanted more structure and needed specific and direct instructions.

Nevertheless, the instructor indicated

> *… even in cases they felt a little uncomfortable maybe at the beginning, with maybe being a little unstructured, maybe having too much freedom, by the end of the course, they really thought that it was the best way and they learned more that way. Having to take charge of their own learning was very empowering to them.*

The third observation made by the instructor was about the voting system. The possibility of being published (Figure 4.: Featured article in *Adult Educator Weekly*) as a featured article seemed to be a minor motivator for the students.

Figure 4: Featured article in *Adult Educator Weekly*

According to the instructor, the voting system provided more of a "social context": the space that everyone would visit, rather than a motivation for high-quality work. Perhaps as a result of this, on average, less than 25% of the students cast votes during the duration of the course. Another reason for the low turnout could be the fact that they had no impact on grades, and therefore there was no incentive for students to vote. The instructor was hesitant to integrate the voting results into the grades because of two factors. The first was that the articles with the top votes might have been the most popular ones, but not necessarily the best-written, and the other was that the voting mechanism didn't ensure honesty in any way. For instance, students could have agreed to consistently vote for each other.

Despite the lack of impact of voting on student grades, the designers and the instructor felt that it should remain in the course. It had its function in the course, similar to comic relief in a drama, adding a fun element to an academic requirement. In addition, for some students, having a featured article published was an acknowledgement of their work.

5.2 Student perspective

> *[The ability to structure your own learning] gave you some sense of agency... And that was really motivating to feel like I was in charge of my own learning. (Student 2014, pers. comm., 13 January)*

Three aspects of this course made lasting impressions on the student. The first was that she was provided with the "rules" on how to succeed in the course. Within those rules, she was given the freedom to explore and conduct research on issues she felt passionate about. This translated into a deeper connection with the activity, and the creation of a sense of self and purpose when writing the articles. This more profound understanding of the topic, together with the ongoing public feedback, created a sense of community, which was the second aspect of the gamified course that the student would remember. This was because the discussions brought together journalists and readers who were both passionate about the same topic. The students were exposed to various insights and perspectives, which opened an avenue for them to make new connections with others in the class. Finally, as mentioned by the instructor as well, the fact that the articles and comments were read by everyone in the class motivated the students to produce high quality work.

The student acknowledged that the role-playing aspect of the course was challenging at first:

> *I was a little bit outside of my comfort zone for a brief moment [...] But once I got used to it, and adapted to the idea that I'm not necessarily playing someone else - I'm just changing the capacity that I'm presenting my work in, [...] that reinforced my ability to do other things, rather than just be a student presenting in a completely structured way.*

Role-playing was important. Seeing themselves as journalists, the student were compelled to synthesize and present information in a manner that would allow someone else to understand it easily. As the student pointed out, the ability to articulate and to educate others on a topic, rather than write just for self-understanding, was one of the most important processes of learning.

6. Conclusion

In this gamified course on adult education, students took on the roles of journalists and readers of a newspaper, and they were given the autonomy to create their own learning experience and define what success meant to them. They engaged and interacted with the content they were most passionate about and their enthusiasm was evident in the high quality work that was produced. An important component of this environment was a responsive feedback system that let students know, in a variety of ways, how close they were to achieving the goal. The responsive and robust feedback also made students feel their efforts were acknowledged and made an impact on others, which provided further incentive to continue the work. Based on the feedback, this gamified course was indeed a successful way to engage and motivate students.

The successful gamification process was a result of taking into consideration and combining four major aspects: good pedagogical principles, the suitable course, the instructor who was ready to take risks and a platform that was accessible and user-friendly. They all had to fit like puzzle pieces (Figure 5: What made the gamified course work) in order to create a learning environment in which the students could reach their highest potential.

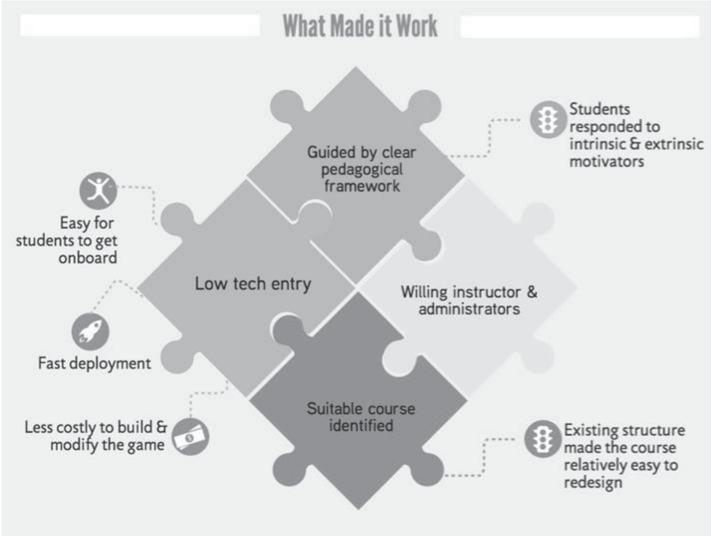

Figure 5: What made the gamified course work

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Learning From Mistakes: A Quiz to Drill Climate Experts

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Abstract: In the context of the Prometeruse project, we are developing a serious game to complement the courses on environmental sustainability that we are delivering in secondary schools across Europe. The project invites academics into classrooms to introduce 14-17 year-old students to the climate sciences and the energy sector. Because the duration of these lectures is limited to a few hours a year, we are coding a web-based Prometeruse Quiz to allow students to gain familiarity with the complexities of these ongoing areas of research in their own time. The game is designed to break scientific facts down into bite-sized trivia questions so that students can learn to juggle the figures and vocabulary of the field in a playful environment. Questions are phrased informally to help students draw relations between their personal experience and the geo-economic data that they are assimilating. However, all answers returned by the quiz include quantitative and technical specifications to sensitise students to the importance of substantiating arguments in factual debates. The game also offers references to primary source material to encourage players to research topics further at leisure. Gamification is enhanced by the opportunity to team up with classmates and compete with peers in schools abroad that are also participating in the project. The quiz cannot substitute for conventional, classroom education. Rather, it takes on the less creative aspects of teaching in order to better prepare students for their classes. The teacher directs students towards information and explains its value. At present, environmental studies sit awkwardly with conventional forms of education given their cross-disciplinary nature and the high degree of complexity at their entry level. However climate change is a topic that resonates with both students and teachers. Exploited well, it could offer a bridge between serious games and more traditional schooling mechanisms, and set a precedent for hybrid forms of education.

Keywords: climate change, environmental sustainability, STEM, serious game, quiz learning

1. Introduction

In spite of mounting scientific evidence of climate change, technological advances towards sustainable solutions and stronger political backing for educational programmes on the subject (Bybee, McCrae, & Laurie, 2009), public concern for the environment has waned in recent years (Stoutenborough, Liu, & Vedlitz, 2014). Politicised public reactions suggest that voters and consumers delegate the matter to their leaders rather than investigate or confront it with their own logic (Hamilton, 2011)(Mccright & Dunlap, 2011). The danger is that growing apathy and lack of knowledge could further restrict the means with which governments can address the matter. This is all the more troubling given the scale of the problem, and the urgency with which these means need to be increased.

As part of international efforts to engage a broader audience, the Prometeruse project has set out to teach teenagers about the root causes and potential solutions to climate change. Its intention is to help them act as information vectors within their families and communities. An important component in our work is to introduce 14-17 year-old students to primary source information on the climate sciences and the energy sector, to help them discriminate between facts and opinions. The introductory lessons are designed, and sometimes delivered, by academics active in the field. Since the course does not fit within national syllabuses and speakers intervene on a voluntary basis, teaching time must be restricted to a few hours a year at each school. This is problematic given the complexity of topics underpinning the climate and energy question. Mastering units and terminology alone can occupy an entire lesson without delivering information on how to deal with the issue.

We are therefore developing a serious game (called the Prometeruse Quiz) to take over the grunt work of our teaching initiative. The game follows a trend in civic education in using networked technologies and a competitive environment to engage players for long enough to grow familiar with the technicalities of the sector (Hammais, Ketamo, & Koivisto, 2014; Reckien & Eisenack, 2013). Drilling gamers in these less creative aspects frees up more time for teachers to draw nuances in the information that they assimilate and put their newfound knowledge to good use.

2. Game mechanics

The Prometeruse Quiz is a web-based trivia challenge in which students log on and compete with each other on questions relating to the environment and the energy sector. Its questions are designed to set the context for classroom lectures and to encourage students to deepen their knowledge by investigating primary source information independently. The game allows students to grow familiar with the concepts and figures that underpin the climate and energy question so that they can make the most of their classes.

To keep the experience entertaining, the Prometeruse Quiz breaks scientific facts and economic figures down into bite-sized trivia questions. The approach mimics flags of the world or movie trivia-based quizzes in its attempt to entertain through gradual improvement at a repetitive challenge. Students can train alone, compete with their class mates or represent their school in weekly competitions against peers participating in the Prometeruse project abroad. The game presents players with a series of twenty multiple-choice questions, each subject to a single choice and a timer (Figure 1). The list of questions is being built-up by teachers and academics as they develop the course material for the project and aims to allow students to train daily while only reencountering old questions often enough to boost their confidence.

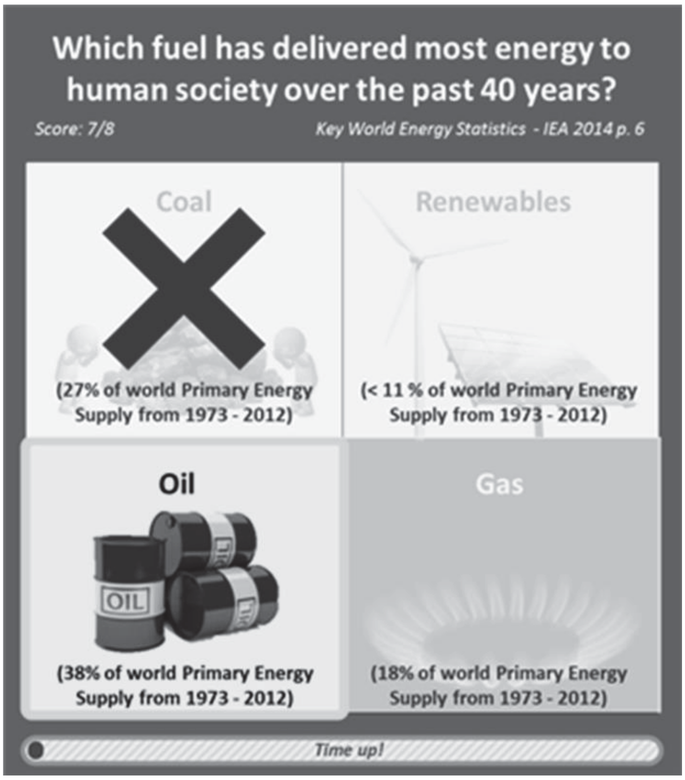

Figure 1: Typical frame from the Prometeruse Quiz displaying a multiple choice question, player avatars on the selected answer, a reference link to primary source material and quantitative substantiation of the correct result

Questions are phrased informally to help students draw relations between their own curiosity and the geo-economic data that they are assimilating. The game is didactic in that, before launching, it offers players study sheets containing information relevant to the topic and provides links to primary source material for each question.

3. Learning from mistakes

One important element in the game is to encourage players to make mistakes. The amount of information offered to students before taking the quiz is dosed to provide familiarity with the topic, without providing the answers. The approach rests on observations that emotional responses (including mild forms of excitement or shame) are more effective at forging lasting memories than exposure to information (Mendler De Suarez, Suarez, Grist, & Pfeifer, 2012). Players are more likely to remember mistakes longer than memorised facts.

The device is being expanded upon by allowing students to log on to the game simultaneously and compete with peers abroad as a team. Each player is personified on-screen with an avatar that moves towards the selected answer before the timer runs out. Because students can see with the avatars of their friends, the approach provides a mild form of peer pressure that incites students to reconsider their mistakes and learn from each other.

4. Hybrid teaching method

The Prometeruse Quiz does not attempt to substitute the teaching element in our project but to complement it in the way that a homework sheet complements classroom work. One potential drawback of assessment-based serious games is the information that they convey is limited to the scope of their designers. When addressing an open-ended topic, like that of climate change, this can lead to shallow learning (Bellotti, Kapralos, Lee, Moreno-Ger, & Berta, 2013). For this reason, we continue to rely on teachers and students to carry the bulk of the learning process and use the quiz as a bonus tool to help them along the way.

In our hybrid teaching approach, classroom lessons are designed to spark the enthusiasm of students and offer them the basic tools (unit conversion rules, concept definitions, mathematical techniques) to address the topic. The serious game allows students to put these tools into practice and process information learnt during the lectures with concrete examples. The synergy between the two equips students to pursue primary source research of their own and broaden their knowledge (Figure 2).

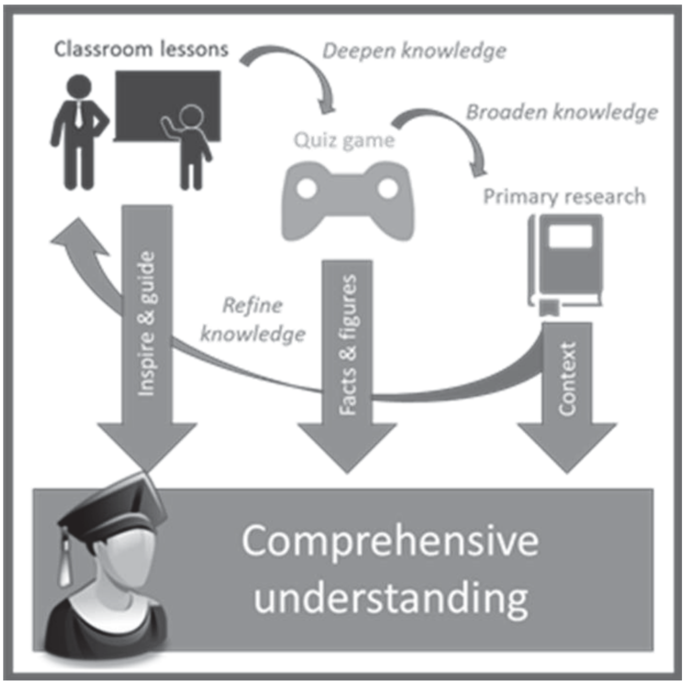

Figure 2: The approach to teaching the Prometeruse course content is a hybrid of classroom lessons, serious game and autonomous primary source research

The Prometeruse quiz encourages autonomy by prompting students to follow links towards primary source material on the questions that it sets. However, there are countless other avenues for initiated students to broaden their knowledge on climate change. They can feed everyday conversations and news articles back to the classroom, shouldering teachers and lecturers with the task that they do best: explaining the nuances in newly acquired knowledge and help to delineate the conclusions that can be drawn from it. Sharing game results and personal experience has been shown to help students crystallise their thoughts on the matters taught (Crookall, 2010) and offers teachers the opportunity to direct student enthusiasm towards coursework goals.

5. Conclusions and perspectives

The pilot version of the game is being field tested over the coming months, and its initial results will be presented at ECGBL conference in September 2015. Full roll out is expected over the course of the Prometeruse project in the coming school year and will mature on the basis of student feedback. We expect to tailor the game level difficulty to each player and optimise the reward mechanisms in order to boost students' play-time and progress on scores (two characteristics that can be followed given the log on details of each player).

Ultimately, the metric of interest is how players alter their behaviour towards the environment as a result of being better informed about it. Interactive virtual experiences have been observed to nurture sensitivity in civic relations exercises (Gordon & Baldwin-Philippi, 2014; Kahne, Middaugh, & Evans, 2008), but there is as yet no evidence that this translates into more responsible action in real life (Wu & Lee, 2015). The Prometeruse project provides a convenient indicator in that the electricity and gas consumption of the school buildings in which the game has been introduced is being monitored. Correlations between improved test scores and decreased energy consumption could testify to the benefits of using serious games as a teaching tool in the struggle against climate change.

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Are Game Mechanics Mappable to Learning Taxonomies?

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Abstract: Can the game mechanics which promote learning be catalogued? To address this question, a framework is designed to investigate both the learning aspect whilst integrating the ludic dimension. In an effort to validate the hypotheses, Bloom's revised taxonomy provides the learning criteria, whilst the game mechanics are provided through the filter of commercial games and gamification systems. Finally, for the purposes of testing, a playable prototype game example is designed and created specifically for the task, containing specific measurable learning objectives, and tested with students, aiming at recording how they perceive the connection between the game mechanics of the prototype and the provided learning elements.

Keywords: game design, game mechanics, learning, learning taxonomies, blooms taxonomy, education, edutainment, serious games, serious gaming, gamification, playful interaction, e-learning, games for health

1. Introduction: The methodology of mapping game mechanics to learning taxonomies

For the purposes of investigating game mechanisms that promote learning, our first hypotheses must be to question if specific game mechanisms are mappable to a recognized learning taxonomy, and if these game mechanisms are able to support and promote learning outcomes. For this purpose, due to its correspondence with various learning mechanisms investigated, Blooms revised taxonomy (Krathwohl & Anderson, 2001) is preferential as a framework due to its simple, easily understandable terminology, i.e. six easily recognisable definitions: remember, understand, apply, analyse, evaluate and create. Bloom's taxonomy will be utilised as a learning framework against which the actual learning can be mapped through quantitative and qualitative research (playtesting, questionnaire, interviews). The gameplay mechanisms provided to the students for prototype creation and case study testing were adapted from the provided literary review, commercial game and gamification mechanisms, and the authors own personal experience within game development. Please note that the list was provided as a guide only – attempting to provide an exhaustive list of all game mechanics is beyond the scope of this study. A student prototype 'Important events in the life of Harriet Tubman' was utilised as the case study in the testing stage. The game development students who created the prototype were given freedom to utilise whichever game mechanics were 'fit for purpose' from the provided list, and also encouraged to utilise their own within the construction of the prototype. Specific utilised mechanics from the list are discussed within the case study and contained within Table 1. An expanded list was made available to all the participants during the testing. For a mechanism to be deemed effective, within a certain taxonomy, it must be mapped to that specific category by the majority of the test subjects within that particular analysis filter. For successful learning to have been confirmed within the context of the study, certain measurable learning objectives were built into the example prototype that must have been seen to be fulfilled. This is discussed within the example case study.

2. Literature review

2.1 Game design

In respect of its aims, game design has many considerations that are unique among other types of software development (Pinelle, Wong & Stach, 2008). Other academics have sought to identify an overarching set of design principles, or principles aimed at specific elements such as engagement, but this study is not directed toward design principles as a whole, rather the mechanics 'mappable' against learning taxonomies. As Deterding argues, 'current models of video game motivation do not connect to the granular level of single design elements' (2011, p 1). This paper aims to provide game mechanics to be tested for such motivation in a learning framework, providing a proven and testable mechanic set from both commercial games and education. As an analytical method, the core pillars of game construction must be considered.

2.2 Game design taxonomies: Basic gameplay loops

To analyse mechanisms in games, we must first understand the basic components. One of the primary functionalities recognized within games is the 'gameplay loop' (Florian, 2012), consisting of objective, challenge, and reward. These elements are discussed below.

2.3 Objectives

Early games such as 'Pong' (1972, Atari) had simple, clear objectives – get the ball past the opponent for a high score. Modern games, although frequently based around a single main objective frequently contain sub quests or side missions, primarily for the purposes of extending playtime or replayabilty. Ideally, game objectives are immediately clear to the player. Clear objectives can also aid learning; a case study of 'the multiplayer classroom' described how, after introducing RPG style quests into her class, a high school biology teacher found that having an objective and reward at the end of the class was 'great motivation for them to do more work' (Sheldon, 2011, p.55). Objectives in games are designed to motivate – are there mechanisms available that will succeed in the same motivation in the learning environment? An example of one such mechanism, used frequently within this field, is narrative. The difference between narrative in games and narrative in other forms of media being that the player has control over the character and, in many cases, the story. Aarseth (2003, p.5) states: 'Players do not regard their engagement with a new literary or cinematic work as a learning process, which every player of a new game must and does.' Jackson (2009, p8) cites narrative within games as aligning with Papert's Syntonic learning (1980), i.e. 'Learning that takes place because the learner identifies with the task, object, context, and/or character'. This agency creates powerful associations for the player, giving a sense of 'ownership [and allowing] a sense of self-control and self-determination' (Gee, 2005). Sheldon also argues that it gives players choices and a 'stake in the game' (2012, p.38).There are many thousands of motivators (as above) utilized within game systems, and drilling down to locate the most effective from a learning perspective is the focus of this study. So, with many ways to motivate, entice and drive the player through the game, which elements or systems represent 'play'?

2.4 Challenges

Csikszentmihalyi analysed the player's sense of 'flow' (1997, p.66), a state achievable through an optimal balance of challenge vs. ability. He describes the ideal requirements: 'Human beings feel best in flow, when they are fully involved in meeting a challenge, solving a problem, discovering something new. Most activities that produce flow also have clear goals, clear rules, and immediate feedback – a set of external demands that focuses our attention and makes demands on our skills' (p.66). Videogame designers have levered the concept of flow and elements such as clear goals and immediate feedback into modern game design for decades (Chen, 2007). Mirrored in the difficulty curve of games, the player is directed towards clear objectives as the challenges in the game increase (Lee & Hammer, 2011). Challenges in video games prevent the player from reaching the goal, or final objective directly. In a correctly balanced game, the player will make many mistakes to reach this objective. Van Eck (2006, p.5) describes the gameplay process as a 'constant cycle of hypothesis formulation, testing, and revision' – and in this scenario mistakes are an important part of the process. Sheldon (2011, p.XV) argues that 'the primary way that players learn is from making mistakes'. Making mistakes in games is indeed a powerful tool, allowing players to experiment with game systems and mechanisms without real world consequences. This raises questions of how to keep players motivated and learning from their mistakes. McGonigal (2011) describes the feeling of player agency as the key: 'the players hadn't failed passively. They had failed spectacularly, and entertainingly' (p. 76). In games such as 'Limbo' (Playdead, 2010) and 'Trials HD' (RedLynx, 2009), the fascinating ways in which the player is able to die are rewards in themselves. As Jackson, says players 'can take risks and learn from their mistakes because they can make multiple attempts' (2009 p.3). Rapid 'respawn' or rapid feedback cycles are vital in this process (Lee & Hammer, 2011). Being delivered back into the game world further re-enforces the lack of consequences. In education, on the other hand, 'the stakes of failure are high and the feedback cycles long' (Lee & Hammer, 2011 p.4). In circumstances where the player is overwhelmed by the challenge, this means no more than re-starting the level or choosing a different route or strategy with which to approach the problem; however, in education, overwhelming the learner with information could be potentially catastrophic. As Jenovah Chen, designer of the influential 'Journey' states: 'simply increasing the number of choices is costly […] when people can't decide what to choose, they are at a loss' (2007, p.33). In the case of mechanisms promoting learning in games, it would seem 'reduced options' are important, certainly in the early or training stages. This directly mirrors a Gamification technique described as 'onboarding' (Zichermann & Cunningham, 2011), where the player is given only limited choices and positive re-enforcement within the first moments of a game; as Zichermann & Cunningham describe 'train and engage, but don't overwhelm' (2011, p.59). Onboarding also finds parallels in Yusoff, Crowder, Gilbert and Wills's 2009 study into a framework for serious games; one of the aspects of a game which supports 'learning and engagement' is 'scaffolding', or 'the support and help given by the game during the learning activities' (Yusoff, Crowder, Gilbert & Wills, 2009, p.22). This also a component of Blooms 'mastery learning', where a student or player achieves a certain skill or cognitive level before the next become accessible or, as Smith puts it, 'to reach the next level of learning, the learner must first master the level before it' (1981, p.7). Jackson (2009, p.4) argues that to keep players within their 'zone of proximal development' (Vygotsky 1978, p 86), or maximum learning zone, a certain level of mastery must be reached before they are allowed to progress. In game terminology this is called 'gating' (Hauteville, 2011), where a player should only be allowed access to a new area when they have mastered the pre-requisite set of skills. Robin Walker, one of the game designers of 'Portal' (2007), discusses this concept in an early introduction to the in game portal mechanic: 'Completing the puzzle requires walking through a minimum of five portals in a specific order. This kind of gating, in which a solid understanding of key gameplay concepts is required for success, helped standardize the learning curve of the game tremendously' (The portal wiki, 2010). Blooms 'cognitive domain' taxonomy (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956) features this 'scaffolding' structure that maps so clearly against 'gating' and the onboarding mechanisms so prevalent within onboarding. This early area of the game, within the context of the onboarding, is frequently referred to as the 'sandbox' area. Not to be confused with the game genre where the player is allowed free agency within the world, sandbox in this instance refers to a safe environment where the player can safely learn new game mechanisms or strategies without threat of death, time limits, or enemies. Aarseth, (2003) describes the learning within a game as a progression of exploring and experimenting with techniques; the sandbox area, where the player is usually required to learn the basics of the game system, is designed for this purpose. Indeed, the sandbox environment seems to mirror basic human learning needs. Bjorklund and Pellegrini argue in their chapter 'Homo Ludens', that 'human children have so much to learn that they require not only a long time to learn it, but also safe environments in which to master their eventual adult roles' (2002, p.331), or, as Gee describes them, sandboxes allow 'exciting play where, in this case, things can't go wrong at all' (2005, p.21).

Learning also requires reflection on what has been learnt, which Yusoff, Crowder, Gilbert & Wills describe from the learner point of view as assessing 'the purpose of the learning activities that have been undertaken, and deciding the strategy to apply during the next activity' (2009, p.23). The sandbox area allows for failure without consequences. Koster argues that 'fun is about learning in a context where there is no pressure, and that is why games matter' (2005, p.99), or as Chatfield argues in his TED talk on game behaviourism, '[give the player things they can] manipulate and play with and where the feedback comes, then they can learn a lesson, they can see, they can move on, they can understand' (Dotsub, 2010).

2.5 Rewards

The next component in the gameplay loop of objective/challenge/reward, rewards are arrangements in the game to encourage the learner and to keep their motivation high. (Yusoff, Crowder, Gilbert & Wills, 2009 p.22). Rewards in commercial games are as varied as auditory and visual feedback, points, levelling and 'powerups'. Feedback is something that games are designed to provide. With the proliferation of motion control devices, games are more than able to deliver the visual, auditory, and kinaesthetic learning style variations familiar to educators. Players receive rapid frequent feedback guiding them to a goal: it is crucial to the player understanding that they are on the correct route. This is referred to by developers as 'signposting' or 'breadcrumbing' (Bacher, 2008, p.14). One of the primary concerns for the designer is that this feedback is happening 'rapidly and frequently' (Van Eck, 2006, p.5) and as Chatfield puts it 'virtuality is dazzling at delivering this' (Dotsub.com, 2010). This rapid feedback is also vital in Learning. Fink argues that feedback should be immediate, and close to the learning activity itself, i.e. 'With delayed feedback […] students cease to care about why their answer or activity was good or not' (2003, p.128). In Gamification, points are utilized as an important reward system. Deterding (2010) argues that rewarding points for the simplest action, the player clicking at regular intervals to receive rewards is valueless. This was satirised by Ian Bogost's cow-clicker (Facebook, 2012), which highlighted the meaningless nature of virtual rewards: Robertson named this 'pointsification' (2010). It mirrors Skinners' 1940 behaviourism experiments; indeed returning each day to tend your crops in Farmville (Zynga, 2009) and its Gamification definition as 'appointment gaming' (Gamasutra, 2010) only serve to re-enforce this view. These same points systems are described as 'feedback loops' (Zichermann, Cunningham, 2011; Kim, 2000); the sense of scores and levels as providing 'clear and unambiguous feedback to the player that she is heading in the "right" direction' (Zichermann & Cunningham 2011, p. 77). But can points ever be recognized as a reward in themselves, other than collecting enough for a 'free coffee at Foursquare' (Lashke, 2011, p.3)? Yes, perhaps in the case of education, they can. Points have different meaning and value within an educational context. Points or grades are markers with which to measure learning. In a real world context, points must be treated carefully; indeed, evidence indicates that children who are good at a particular activity will lose interest once rewards, trophies, or competition are introduced and/or removed, a concept known as 'over-justification' (Zichermann, 2011b). Other successful reward systems should be noted; 'achievements', popularized by the Microsoft XBOX and now an 'integral part of Xbox 360 gaming' (Jakobsson, 2011), involve rewards being afforded to the player for completing particular in game quests, or in many cases unique challenges set by the game designers, i.e. 'Perform an air assassination on a poisoned NPC' from 'Assassin's Creed 2' (Ubisoft, 2009). Badges, the gamification version of achievements also allow the player 'bragging rights' (Deterding, 2010), or an opportunity to show off their accomplishments (Zichermann, 2011) or, in cases such as 'GetGlue' (GetGlue, 2010), personalize their television viewing preferences and discover like-minded companions. Deterding (2010), argues that bragging rights are a predominantly male interest, and target audiences must be investigated carefully. Is there a place in the classroom for a version of bragging rights? Certainly, if handled correctly, elements such as avatar improvements (i.e. new outfits and personalization for your player character) serve both ownership and promote engagement with the game, and perhaps learning environment.

3. Example case study and testing

3.1 Research methodology

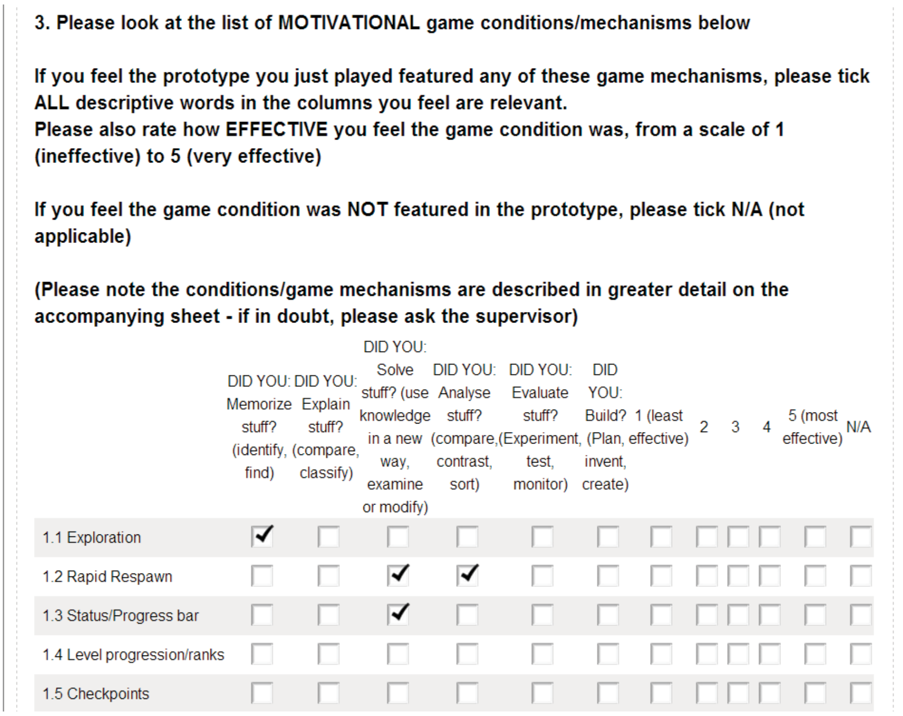
As discussed Bloom's taxonomy is utilized as a form of classification (Butler, Markulis & Strang, 1985, p.86), the goal of the research being directed specifically toward correlating Bloom classification against game mechanics.

3.2 Quantitative/qualitative data

The questionnaire was organized with the aims collecting the largest amount of information in the most efficient way for analysis. In that respect, a quantitative digital survey was organized, while qualitative data and feedback was observed and collected on the test days.

3.3 Test specifications

The Bloom's taxonomies' conditions were displayed against mechanics, as per the example below (fig. 1). The component sets were the students were allowed multiple inputs in each bracket of Blooms taxonomy.



3. Please look at the list of MOTIVATIONAL game conditions/mechanisms below

If you feel the prototype you just played featured any of these game mechanisms, please tick ALL descriptive words in the columns you feel are relevant.
Please also rate how EFFECTIVE you feel the game condition was, from a scale of 1 (ineffective) to 5 (very effective)

If you feel the game condition was NOT featured in the prototype, please tick N/A (not applicable)

(Please note the conditions/game mechanisms are described in greater detail on the accompanying sheet - if in doubt, please ask the supervisor)

	DID YOU: Memorize stuff? (identify, find)	DID YOU: Explain stuff? (compare, classify)	DID YOU: Solve stuff? (use knowledge in a new way, examine or modify)	DID YOU: Analyse stuff? (compare, contrast, sort)	DID YOU: Evaluate stuff? (Experiment, test, monitor)	DID YOU: Build? (Plan, invent, create)	1 (least effective)	2	3	4	5 (most effective)	N/A
1.1 Exploration	✓											
1.2 Rapid Respawn			✓	✓								
1.3 Status/Progress bar			✓									
1.4 Level progression/ranks												
1.5 Checkpoints												

Figure 1: An example of the online case study questionnaire format

Table 1: Abridged/example list of primary case study game mechanisms (as provided to students)

	Name	Description
Teaching	Safe environment (Safety first!)	Players should always be given the tools and taught the initial steps of any gameplay mechanic or system in a safe environment!
Teaching	Readability/consistent rules	Once you've taught the player a visual language, you MUST adhere to that visual language (E.g. the colour coded environment of Mirrors Edge))
Teaching	Embed/embedded	Important knowledge or information can be embedded in cutscenes, audio logs, or environment. (E.g. Bioshock, Left4dead intro movie)
Objectives and Motivators	Multiple quests	Give the player other routes when tired of the main quest
Objectives and Motivators	Storyline	The story of the game is motivating the player to keep playing and exploring the world
Objectives and Motivators	Signposting /breadcrumbing	Lead the player via lights, medi-packs etc.
Challenge	Free access (Roaming)	Allowing the player access to areas with challenges outside of the regular difficulty curve – allowing for bonuses – or death!
Challenge	Pattern recognition/memory	Learning certain game patterns or systems that result in modifiers or other rewards.
Win/Lose	Subterfuge	The player has to accomplish a certain objective without being detected or revealed

3.4 Test subjects/location

The testing took place within the faculty for International Game Architecture and Design, part of NHTV University of Applied Sciences campus, Breda, Netherlands, using first year students enrolled on the game design fundamentals course, from the programming and Independent game development streams. The students were all computer literate and well versed in the ethos of gaming. This information was validated by strict initial tests for entrants to each of the streams. The majority of the students comprised of English speaking Dutch or German students, with a minor representation from the UK, Poland, and Russia. The game design fundamentals' course taught to the students involved was designed to describe the basic component sets, and mechanism subsets, that make up commercial games. These were investigated across a variety of provided game genres in the classroom environment, and a card set provided describing these mechanisms was created and made available (Fig.2). This process was used as an introduction to the full mechanic set (examples within Table 1). This game component and mechanic focussed card set was informed and inspired by 'The deck of lenses' (Schell, 2008) card set based around the popular 'The Art of Game Design: A Book of Lenses' (Schell, 2008).

4. Example case study – 'Important events in the life of Harriet Tubman'

4.1 Overview

'Important events in the life of Harriet Tubman' is a first person view prototype game developed in the Unity engine, based around Harriet Tubman, an influential female figure within the slave abolitionist movement during the American civil war. This game was based in a large open world environment based around the geographical locale of Maryland. Nine participants took place in the case study.

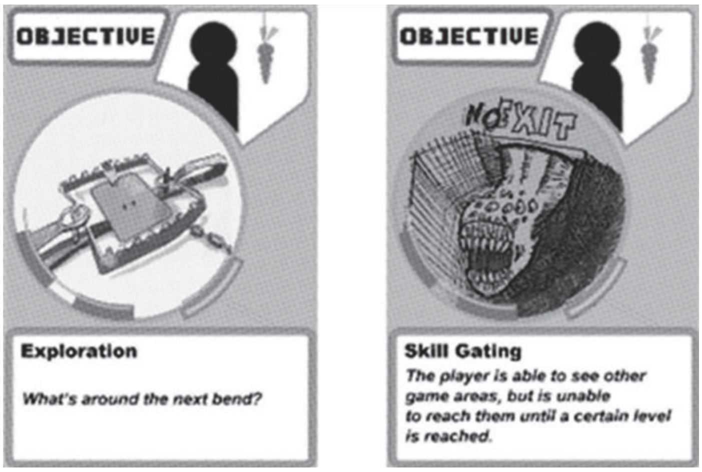


Figure 2: Example game mechanic cards

4.2 Learning objectives

In the context of Bloom's taxonomy, the creators specified two learning measurable learning goals based around 'remembering' and 'understanding' in the revised taxonomy – more specifically that the player remember and understand information regarding Harriet Tubman and her role within the abolition of the slave movement. This information was delivered via the loading screen, and within the descriptions provided by the quest givers. If the quests were accepted in order, and hence all of the historical information built into the game provided in order, for the purposes of the study, the learning objective within the context of the game was recognised as fulfilled.

4.3 Game objectives and primary featured mechanisms

A description of the case specific game mechanisms within the context of the case study follows. These are presented as per the order of introduction within the game and shown in italics. The same mechanics are also specified within Table 1. The Primary game objective was to find the underground railway, and escape the area, as introduced via a notice board beside the player start position (fig. 3) other information, such as a map of Maryland was *embedded* within the loading screen, outlining the events and objectives in a historical context;

Figure 3: The noticeboard at the start of the game

Figure 4: The first *quest giver*

Game objectives were delivered by a number *quest givers (*fig 4), who also introduce a *storyline* element, as well the initial *exploration* objective of finding the next *quest giver* within the woods surrounding the player.

The player has no specific boundaries, and is allowed *free access/roaming* across the majority of the map, other than areas where they are corralled or blocked by raised ground at the edges of the playable area. This *safe environment* promotes exploration, the only real challenge in the game being slaver camps (fig.5), which, if approached, display an on-screen warning to move out of view. The player is guided, or *signposted* in the correct direction by gas lamps (fig.6), and upon reaching the second quest giver, is directed toward a side mission, *collecting* pages of a diary scattered through the woods. The second quest giver also warns about following the road, promoting the *subterfuge* mechanic. Finally, *pattern recognition* is noted – learning the placement of the enemy camps is an important aspect of progressing.

Figure 5: Enemy camp notification

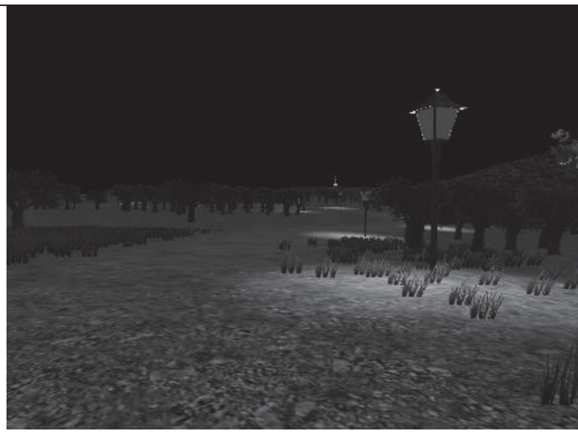


Figure 6: Signposting

5. Results; – 'Important Events in the Life of Harriet Tubman':

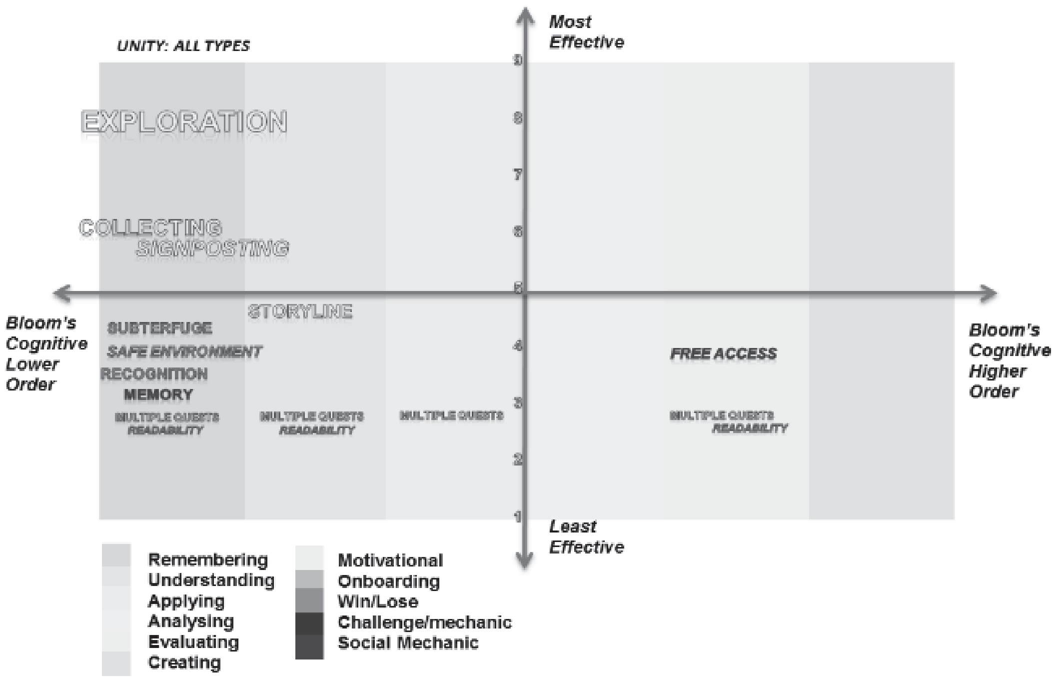


Figure 7: Results for all player types

As described in (fig. 7) *Exploration* was found to be the most prominent mechanic, with eight out of the nine participants mapping it against the remembering category of Blooms. In the context of the information provided by the quest givers i.e. 'go to point A, B, etc.' *exploration* seems closely tied to the remembering aspect of Bloom's taxonomy. It is noted that a number of participants headed for the visible spire of a distant church. On arrival, a quest giver informs them 'there is nothing here, please go away!' (Bloemhoff, 2013). Or as a player noted; 'Exploration is not rewarded, even though it is encouraged by points in the distance (the church)' (fig.8).

This comment suggests that exploration is expected to be rewarded in some way – even if the reward, in the case of the other *quest givers* is simply information guiding them to the next objective. In the context of a learning situation it would seem that information itself can be seen as a reward as long as it is guiding the player toward an objective. Within the higher leaning objective of evaluation, *Free Access/roaming* rated relatively highly. Once provided with quests, players would probe the environment testing various routes out to see which one was most effective or garnered the most rewards. *Collecting* again introduced by the *quest givers*, clearly maps alongside *exploration* within the remembering category of Blooms. Even If this sub-quest is not investigated by the player, is this also perceived as a reward? Could this type of sub-quest be used to 'sugar coat' learning information? *Signposting* and *subterfuge* as information received from the quest givers i.e. 'stay on the road' and 'avoid slaver camps' are also mapped into the remembering category. This would seem to link directly to the necessity of remembering the route or map layout. One explorer player notes; 'Trying to not get detected when reaching a goal is a quite powerful win/lose condition'. *Storyline* was also relatively highly placed within the understanding category, although actual story featured minimally within quest objectives. It seems *storyline* is keenly sought by game players.

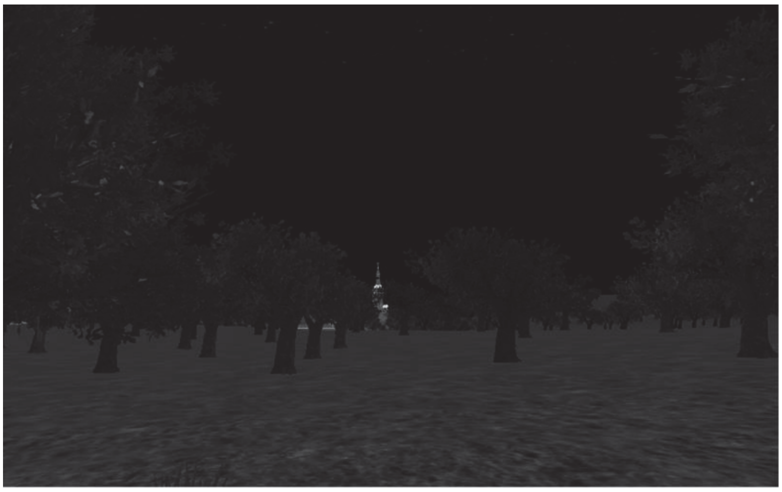


Figure 8: The distant church

6. Conclusion

This example case study investigated the possibility, via the frameworks of player types and learning taxonomies, a system of measuring the 'success' of game mechanisms that guide the player to learning. Although mechanisms can clearly be mapped to learning taxonomies, other variables apparent within the case studies must be taken into consideration. Game genre is a vital factor in how a mechanism is perceived. For instance, *exploration* within an open world game that seeks to simulate elements of the real world is perceived entirely differently in a stylised 2D platformer that focuses on interaction between objects. The learning goals in this study were assumed to be achieved to by completion of a wide range of player tasks such as 'completing the level'; this suits for a umbrella categorization of all mechanisms within that completed level as promoting learning, but for a more precise study of the efficiency of particular learning outcomes granularity must be addressed; It would be suggested that real, measurable, testable learning content must be built into the game if future work is to be conducted in this area. In addition, the inclusion of some form of player type taxonomy is suggested with regards stereotypical behaviours and how they motivate the player type; i.e., do explorers or gatherers aim to find new and unique areas and then share their new knowledge, or as Bartle (1996, p.4) puts it 'making the most complete set of maps in existence'? Do killers head straight for the objective without taxing themselves with the digression of exploration? Although further research is clearly needed in this area, if a definitive taxonomy of testing was constructed which aimed to recognize the game mechanisms that promoted learning, this may form an important part of developing didactical structures to promote learning of knowledge and skills across all ages and learning groups.

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Gamification and Lifestyle Technologies for Personal Health Management

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Abstract: This paper presents a practical case study on the use of Gamification strategies and wearable lifestyle technologies for personal health management. It describes the results of a two year project in which the author explores the potential of various lifestyle tracking and health monitoring equipment and the impact that had on his health parameters and well-being. The paper will describe the lessons learned from project and the techniques used to effect simple but long-lasting changes in exercise and eating patterns that significantly improve personal health management. The data captured and visualized by the mobile applications linked to these lifestyle technologies illustrates how gamification and enabling technologies have evolved in support of pervasive personal health management. The paper will also suggest how these technologies and practices are likely to evolve over the next few years and the potential benefits for society in tackling global lifestyle related conditions such as obesity and diabetes.

Keywords: gamification, health, lifestyle technologies

1. Introduction and background

Lifestyle related conditions such as obesity and diabetes represent one of the most serious challenges to global health which threatens the sustainability of health services. In countries like the UK, there are regular headlines about the likely consequences of growing levels of obesity, especially in children, for future generations. The challenge therefore is to find sustainable practices which tackle this issue successfully and avoid the serious consequences of a breakdown in health services and consequent incidence of avoidable mortality.

There is a general acceptance of the need to change lifestyle behaviours of all ages of citizens but there are a number of important barriers to affecting these changes which include :-

- Lack of motivation and practical inability to change lifestyle
- Lack of awareness and understanding of the consequences of obesity on future health
- Ready availability and attractiveness of fast food with poor nutritional content
- The belief that free health services on demand will be available when needed
- A model for health insurance which does not link premiums to lifestyle behaviours

These factors, coupled with a perception that the Government should take responsibility for ensuring the health of its people, leads to demands for Government intervention on issues such as sugar content in food, penalties for poor fast food provisions and the display of nutritional content on food packaging.

All of these suggested interventions are designed to allow citizens to continue their chosen lifestyle practices without any responsibility for managing their own health.

This situation is increasingly unsustainable and requires interventions which facilitate a shift change in the citizen’s acceptance of more responsibility for personal health and the necessary tools, motivation and incentives to change lifestyle practices in a positive way.

2. Case study on gamification and wearable technologies for personal health education

This paper explores the impact of disruptive technologies such as the internet of things, big data and wearable technologies on personal health management and is based on a case study carried out over the last 2 years by the author who has explored the potential of these technologies to improve his own personal health management.

Figure 1: Impact of case study on the author's appearance

Figure 1. Illustrates the impact of the project on the author's change in appearance over the two years of the project. The majority of the weight loss (21Kg) was achieved within 3 months of starting the project in June 2013. Health Education is a very good example of the difference between Education for the acquisition of Knowledge and Education to influence behaviours, understanding and actions.

At the start of this project, the author was obese and in a pre-diabetic condition but these circumstances, although lifestyle related, did not present any serious medical problems or impact on the author's daily life. As a consequence, although aware of his obesity, the author was not motivated to make any changes to his lifestyle or undertake education activities to improve his knowledge or understanding of the potential long term consequences of his condition.

Without motivation for change or incentives to better understand and adopt best lifestyle practices, the author was not engaged in developing personal healthcare management skills or practices and would have been reliant on corrective medical interventions instead of preventative interventions. The author would not have been truly engaged in the personal health education initiatives available and increasingly promoted today because, although health knowledge was of interest, it made no impact on the author's daily life. The author was effectively a "spectator" of his own health rather than an engaged practitioner.

It was combination of circumstances in June 2013 which led the author to explore the potential of gamification and wearable technologies for personal health management. The primary factors for triggering this activity were the discovery from a DNA analysis that the author has a 32% probability of contracting Diabetes 2 and reading an article on the BBC website about wearable technologies.

2.1 Gamification, measurement and feedback

The case study involved wearing fitness tracking bracelets which measure physical activity and sleep, collect the data and display the results within free mobile applications. These devices and applications combine gamification strategies, sensor technologies, cloud computing, big data analytics, data visualization technologies, wireless broadband, artificial intelligence, mobile devices and social media.

Figure 2: Example wearable fitness devices used by the author

Figure 2 shows two of the devices used by the author during the case study. One of the devices, the Jawbone UP device provided a smartphone application which not only shows trends in physical activity and sleep patterns but also provides tools to calculate calorie consumption and nutrition based on food and drink consumed. This requires the user to enter the food and drink manually and, in some cases, to enter the nutrition data found on the food packaging.

The key factors for influencing behaviour in this project are automatic measurement and feedback, coupled with good data visualization that assists understanding. The fact that the data is personal and is displayed on demand in a format which helps the user to understand the impact of their actions leads to immersive learning linked to behavioural change and putting into practice the lesson learnt.

Immersion in the process of self-directed learning informed by automatic data collection and analysis provided for better understanding of health management and, more importantly, practical implementation of changes in lifestyle.

3. Conclusions - pervasive gamification and self-directed personal healthcare

Immersion in any activity by focusing attention and limiting distractions helps to facilitate absorption of knowledge but does not necessarily affect behaviours or develop understanding and skills. Behavioural change can be influenced by motivating factors which can either be extrinsic or intrinsic or a combination of both.

Extrinsic motivation can be provided by potential rewards e.g. money, qualifications, penalties for failure whereas intrinsic motivation comes from the pleasure and satisfaction of the activity. Games generally provide intrinsic motivation and more sustainable outcomes whereas extrinsic motivation in behavioural change whilst it can support the acquisition of knowledge, is less likely to be sustainable and have a long term impact on behaviours and true understanding.

The main conclusion drawn from this case study exercise is that disruptive technologies which provide ambient and automatic personalized performance measurement and feedback coupled with good data visualization and “Smart” coaching not only creates a far more engaging experience but also goes beyond the acquisition of knowledge into greater levels of understanding and behavioural change.

Since the original drafting of the paper, the author has been involved in 3 European projects which apply the same principles to target both physical and cognitive wellbeing improvements through the use of gamification strategies and games-based technologies. The PEGASO project (http://www.pegaso4f4.eu/) uses wearable technologies and games to encourage healthy lifestyles amongst teenagers whilst the DOREMI project (http://www.doremi-fp7.eu/) uses games technologies to promote healthy ageing. The Rehab@home project uses the Microsoft Kinect to support physical rehabilitation in the home environment whilst the data analytics from the games support medical professionals to assist with customised rehabilitation programs. All these project applications involve development by Italian Serious Games specialists, Imaginary.

Work in Progress Paper

Towards in Situ Measurement of Affective Variables During Playing Educational LARPs: A Pilot Study

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Abstract: Live action role playing games can be used for educational purposes (edu-LARPs), but information about their learning effectiveness is limited. To our knowledge, even quantitative instruments for in situ measuring (i.e. during playing the game) of affective constructs, for instance flow or generalized positive and negative affect in edu-LARPs, are lacking. Existing instruments cannot be applied straightforwardly due to several reasons; most notably, because they are not gamified. Administering a non-gamified inventory in the game can influence/interrupt the states it is supposed to measure. The research aim of our new project is to investigate acquisition of mental models of mechanical devices learnt within an edu-LARP and correlate the quality of the acquired mental model with in situ flow and generalized positive/negative affect (planned N ~ 10 groups x 10 participants). So far, we have conducted three pilots (N = 10, 12, 13) for which we developed a new method for assessing these constructs by in-game questionnaires (and tested the LARP's plot, a sci-fi space opera). The results so far are promising in that we are able to administer the respective questionnaires in situ without adverse effects of the measurement process on these states; as reported by participants in post hoc focus groups. Our method can be probably used in other edu-LARPs provided certain requirements on the LARP's plot are met. Another result is that some components of flow (such as fluency/sense of control) seem to be influenced by role playing but others (such as absorption or time alteration) not so. This indicates that the notion of flow as a unitary construct may not be applicable in LARP contexts.

Keywords: educational life action role playing, edu-LARP, mental model, flow; positive affect, learning

1. Introduction

In our research, we investigate the question whether educational life action role playing games (edu-LARPs) can facilitate learning of mental models; that is, acquisition of complex knowledge about mechanisms and processes. It is supposed that LARPs can be used for educational purposes (e.g., Gjedde, 2014), but information about their actual learning effectiveness is surprisingly scarce and it comes mainly from neighbouring research fields. For instance, role-playing activities are effective in reducing student racial prejudice (McGregor, 1993), weeks-long experiential learning courses have positive effects on leadership, self-concept and academic and interpersonal outcomes (Hattie & al., 1997), and educational computer games can facilitate complex knowledge learning (e.g., Wouters et al., 2013). However, we are unaware of a quantitative study investigating directly acquisition of mental models in edu-LARPs.

Our hypothesis, stemming from the field of emotional design in multimedia learning, is that positive affect and flow, experienced by LARP's participants, may boost effectivity of mental models learning (cf. Um et al., 2012), compared to an emotionally neutral condition. To investigate this hypothesis, we designed a 2-hour long edu-LARP, in which a 15-min long learning experience is integrally embedded in the middle. We devised an appropriate knowledge test and also attempted to develop flow/affectivity instruments, but in the latter endeavour, we encountered a problem, which is in the scope of this paper.

Validated instruments for measuring flow and generalized affect exist, such as Flow Short Scale (FSS) (Rheinberg, Vollmeyer, & Engeser, 2003) and PANAS (Watson, Clark, & Tellegen, 1988), respectively. However, from our previous research on computerized educational simulations, we know that participants' flow and generalized affect can differ in different parts of an hours-long intervention (unpublished data). Therefore, in the present LARP study, we need to administer the flow/affectivity instruments in situ (i.e. *during* the LARP immediately after the learning period) rather than post hoc. There are two problems with this: a) administering an inventory during the game can disrupt the states it measures, b) participants are playing a role in the game and their answers in the in-game inventory can differ based on the perspective taken (the player vs. the player's role). The problem would be even more pronounced if presence/immersion inventories (e.g., Jennett et al., 2008) are adopted, because these force the participant to alternate between the two perspectives during completing the inventory (which may further influence flow and affectivity). It was therefore needed to devise a special procedure for administering the inventories.

The goal of this paper is to introduce our edu-LARP (Section 2), present how we managed to measure flow and generalized affect in situ (Sections 3, 4) and highlight one additional issue with measuring flow in LARPs (Section 4).

2. Intervention

After running three pilots with young adult participants (N = 10, 12, 13; M_{age} = 30±5.5), we agreed on the following LARP plot, a sci-fi space opera: In the midst of a journey on a generation spaceship, which is supposed to reach its destination after a thousand years, astronomers discover a previously unknown habitable planet only a couple of years of travel away. The crew leaders decide not to guide the ship toward the new planet; arguing that this would deplete all fuel reserves. They also state that the planet is likely a worse bet than the original target. A riot inserts technical school students (the players) right in the middle of the events. Led by their teacher (the game master), they have to master a device for controlling correction motors and negotiate the ship's final destination. Two equally strong groups of players (pro vs. against the turn toward the new planet) compete for access to the device and eventually either change or do not change the ship's route.

The game lasts about 2 hours and takes place in a faculty building in six rooms/corridors about 600 m^2 large in total. The plot is designed so that all players have to learn how to operate the device in order to win the game (their learning outcomes will be compared to outcomes of participants learning how the device works in a non-LARP context). We intentionally teach the players a fictitious device to avoid issues with high prior knowledge.

The experiment schedule is depicted on Figure 1.

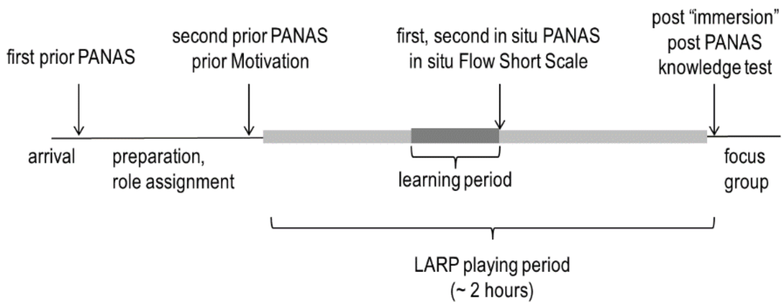

Figure 1: Experiment schedule

3. Inventories

We administer two PANASes prior to the intervention (after the arrival and after the role introduction) along with a prior motivation questionnaire. We also administer the PANAS and a derivation of an "immersion in games" questionnaire (Jennett et al., 2008) post hoc, along with a knowledge test.

Most notably, we administer two gamified PANASes and one FSS in situ, immediately after the participants has learnt how to operate the device (Figure 1). The procedure for administering these three in situ questionnaires is as follows:

- Before the game, we stress the participants that they will receive three gamified questionnaires during the game, and that they should answer questions therein *from the player perspective* (and not from the role perspective).
- Immediately before the learning period, the teacher tells the students – in the game – that they are supposed to fill in a regular survey (after the learning part) which will be used by the spaceship's management to assess quality of his teaching (i.e., gamifing the inventory). This is to make the players see the questionnaires as part of the game.
- Immediately after the learning part, the teacher administers the questionnaires (that take about 5 min to complete in total). The time instructions for PANASes is "assess your emotional states before/right after the learning", and it is "during the last 30 min" for the FSS.

4. Results

The exact PANAS/FSS scores are irrelevant for present purposes because we also worked on the story plot (which improved during the pilots). For present purposes, the key finding is that the majority of participants (> 80%) reported in post hoc focus groups no problems with filling in of the in situ questionnaires from the player perspective. They also reported no adverse effects of the measurements on their affective/flow states. This indicates that the procedure described in Section 3 works reasonably well.

However, we noticed comparatively lower scores from two FSS questions: “I know exactly what I have to do.” and “I feel that I have everything under control.” (4.18±1.38 [±SD] vs. 5.33±1.44 for the remaining questions; on a 7-point Likert scale). This is actually not surprising because at that moment of the game, players (and their roles) indeed could not know exactly what to do and it was in fact vital that players did not feel that everything was under their control (otherwise, the plot would not be sufficiently challenging). Because that can happen in many LARPs, it seems that either not all flow dimensions must necessarily be experienced in LARPs (flow can be conceptualized as a multidimensional construct, e.g. Moneta, 2012; and we are speaking here about “fluency” or “sense of control” dimension) or they are experienced, but these two questions from a validated instrument do not work well in the context of role playing activities.

5. Conclusion

As part of our three pilot runs of an edu-LARP on acquisition of mental models, we devised a method for administering short inventories in the game. Our present results indicate that our method works reasonably well. We believe that it can be used in other edu-LARP, but four things are probably needed should in situ measurements work: a) players are notified in advance (i.e., before the game); b) it is explained to the players what perspective they should adopt when filling in the questionnaires (the player vs. the role); c) it takes a short time to complete the inventories; d) players perceive administering the inventories as part of the game and the inventories’ content is aligned with the instruction given in the game.

Another result is that some components of flow (particularly fluency/sense of control) seem to be influenced by role playing but others not so. This indicates that the concept of flow may be more heterogeneous in role playing activities compared to other activities supposed to induce flow.

Acknowledgements

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Increasing Student Engagement With Gamification

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Abstract: Educators are currently facing the problem of students not fully engaging with the curriculum in educational institutions. Gamification is the application of game elements to real life tasks, which can help change behaviour, improve motivation and enhance engagement. By gamifying the students' learning experience we can improve student engagement, increase their motivation to learn and help further their involvement in their own education. For this reason we are setting out to answer two questions: How much does gamification influence student engagement? , Which game elements are most effective? This paper will look at the use of a specially constructed online learning platform to monitor the engagement of a third level computing course through the students' interaction with the platform. By adding different game elements to various versions of the learning platform, we aim to gauge the success of each element and measure the effect of game elements on student engagement. The platform as a whole will provide students with the ability to set their own learning outcomes and view the progression of their goals. By incorporating game elements into the platform we can give users more frequent and enticing feedback to achieve flow, and use progression loops to help students with onboarding and mastering. By increasing the students' engagement using these game elements, it is hoped that they will feel a greater intrinsic and extrinsic motivation and in turn will spend more time learning. The students' engagement will be measured through their interaction with the platform and feedback from the students' on the felt motivational effect of different game elements. By analysing the data gained from this project, we hope to determine to what effect and degree different game elements engage students.

Keywords: gamification, engagement, motivation, game based learning

1. Introduction

Student engagement can be measured as the time and effort students put into activities benefiting their own education, and activities that are empirically linked to the desired outcomes of their institutions (Kuh, 2009).

As student engagement is shown to be linked statistically to the rate of student graduation in these institutions (Price & Tovar, 2014), it is hoped that an increase in student engagement through gamification will result in increased a higher rate of graduation.

Gamification is "*The application of gaming metaphor to real life tasks to influence behavior, improve motivation and enhance engagement"* (Marczewski, 2013)

It is defined by Deterding as "*the application of game design elements in non-gaming context*'" (Deterding et al., 2001).

As games are based on design choices which successfully keep their users engaged and interested, there is an expectation that by introducing game elements to a system you can increase engagement (Hamari et al., 2014).

However, little empirical evidence has been gathered on gamification so far, both in general, and on its effect on student engagement in the context of 3rd level education (Hamari et al., 2014)

2. Related work

As of 2015 there has already been some minor success with research into the effect of gamification on student engagement.

A study of tertiary students in Sydney (Paisley, 2013) found a significant increase in students' perceived engagement as well as an increase in their perceived motivation with the implementation of gamification.

In a similar study on the effect of gamification in higher education by the Lublin University of Technology, students in a gamified group had a higher attendance and completed more assignments than those in a non-gamified group (Laskowski & Badurowicz, 2014), showing a greater engagement with the course work. The

University of Macau found students preferred using online games to learn vocabulary as it better facilitated vocabulary retention and was more fun. (Lui, 2014).

In 2012, AutoCAD ran an in-house study using GamiCAD, a gamified tutorial system, and found that those using the GamiCAD system completed tasks faster and felt more engaged with the system then those using an equivalent tutorial system without the gamified components (Li et al., 2012).

There are also a number of commercial online educational gamification systems such as Khan Academy (https://www.khanacademy.org/), Code academy (http://www.codecademy.com/), and Goalbook (https://goalbookapp.com/).

Gamification has also seen a popularity increase in private industry with companies using gamification to train and motivate employees.

Successful gamification companies Axonify (http://www.axonify.com/), BadgeVille (https://badgeville.com/) and MLevel (https://www.mlevel.com/) promise to improve employee engagement by providing businesses with specialized e-learning systems.

The MBA social network *Beat the GMAT*'s integration of game elements with *Badgeville* resulted in a 200% increase in page visits and 370% increase in time spent on the site.
(http://www.beatthegmat.com/).

3. Game elements

Gartner estimated that 80% of gamified systems are likely to fail due to poor design (Gartner, 2012). As a result, design of the system and its component game elements is of paramount importance.

To this end, this project will use Human Centered Design (HCD) to design the gamification system.

HCD is "a procedure for addressing these requirements, but with an emphasis on two things: solving the right problem, and doing so in a way that meets human needs and capabilities." (Norman, 2013)

Gamification uses a combination of intrinsic and extrinsic motivators in order to raise motivation and engagement (Muntean, 2011). Extrinsic rewards such as levels, points, badges can be used to improve engagement while intrinsic motivators increase feelings of achievement and autonomy (Richter et al, 2015).

For the design of the system, areas of interest include progression loops and the achievement of flow, a mental state which is characterised by a "complete immersion in what one is doing" (Csikszentmihalyi, 2000).

Visually, clear goals and immediate feedback can help to facilitate a state of flow in the user (Csikszentmihalyi, 1990).

Progression loops can be used to help onboard new users and introduce new elements by breaking the process into multiple smaller progressive steps (Richter et al, 2015).

Progress bars and badges allow the user to see their current progress and help set personal goals (Growth Engineering, 2014), while user profiles and personalized feedback can give the user a sense of autonomy and reflect their own specific interest (Rijmenam, 2015).

4. Methodology for evaluation

To measure engagement we will create three web-based gamification systems that will each differ by a single game element, enabling the effectiveness of that particular game element to be gauged.

The gamification system will be used across a number of modules in a third level computing course, and a study will be conducted using a *within-subjects* experimental design where students will use the different versions of the gamification system in different modules of the same course.

The students' interaction with the gamification system will be monitored as they use it throughout the study to determine the effect each system has on student engagement.

Data will be collected through the student's interaction with the system and any change by the student will be stored and dated in the server's database.

Feedback of the system from the student's will be collected from focus groups, semi-structured interviews and Intrinsic Motivation Inventory (IMI) questionnaires used to assess participants' subjective experience (Ryan, 1982).

We will then perform a comparison of key measures of engagement of learners to estimate the degree to which engagement is increased using the gamification system.

These measures will largely be computed automatically in the system (for example, frequency of use and progression rate) but will also include subjective measures (such as the felt motivational effect of particular game elements).

Using statistical techniques such as ANOVA, the data will then be analysed to track the different degrees to which user engagement can be increased by using the gamification system, and the effect particular game elements have on the student's engagement.

5. In conclusion

Gamification in education is not a new idea with educators already unknowingly using game elements with the rewarding of completed assignments with points (grades) and the progression of a student's level at the end of each year.

However there needs to be a deeper study of the application of game elements in education. To truly realise a student's potential, they need to be fully engaged in their learning (Parsons & Taylor, 2011).

The current empirical research on gamification largely supports the view that gamification produces positive effects (Hamari et al., 2014).

Caution is needed however as stock gamification approaches will not benefit everyone (Fitzsimmons, 2014). The overuse of extrinsic rewards such as badges and points may lead to a disengagement with the system as such rewards need to be meaningful to the user for them to engage with the system (Nicholson, 2012).

It is hoped that this project will deliver an improved understanding of the effect of gamification on student engagement, which may then result in systems that will enhance students' engagement.

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Board Games to Learn Complex Scientific Concepts and the "Photonics Games" Competition

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Abstract: Board games can be useful supports for the exposition and explanation of complex scientific concepts. In the past years we realized and tested three different board games of this kind, presented on the occasion of three different editions of the "Festival della Scienza di Genova" (and of other minor events) in the form of giant live-version board games: "Quantum Race", for the introduction of Quantum Mechanical principles such as wave functions, delocalization, collapse and tunnel effect (2011), "Lab on a chip", for an introduction to the immune system and to Nan biotechnologies (2012), "Time Race", for the introduction to Special Relativity and to the concept of time dilation (2014). Each game has been played by about 1000 participants, mainly students, with excellent results concerning growth of interest and comprehension on the themes. In the ambit of the European Project Photonics4All and of the UNESCO International Year of Light 2015 we are now trying a step forward with a competition for high school Italian students concerning the creation of didactic board games on the themes of light and photonics to be held in the 2015-2016 autumn-winter period. We present in detail these activities with obtained and expected results and issues.

Keywords: board games, science dissemination, quantum mechanics, relativity

1. Introduction

Some scientific concepts present difficulties in the exposition and explanation to non specialists (Perkins 1999, Meyer 2003, Perkins 2010) mainly because 1) they are far from the everyday experience of people and 2) it is difficult to find examples and analogies which can help their introduction in the absence of adequate mathematical tools. Typical examples can be found in Quantum Mechanics and in Relativity Theories.

Games expressly developed for this task (Gee 2007a, Gee 2007b, Whitton 2010, Whitton 2012), in particular board games in our specific case (Gobet 2004), can be a valid support in the spreading and teaching of such concepts. Let us start by recalling some simple and general considerations on board games and their impact:

- The playful and immersive nature of board games facilitates attention and concentration of players;
- During the game there is a "suspension of disbelief" and players are prepared to accept concepts even far from their everyday experience;
- Thanks to competitiveness and will to win the players are urged to deeply understand the rules behind the game;
- The typical downtimes of a board game promote reflection and discussion among players;
- These downtimes also allow the inclusion of clarifications and explanations in a natural and not disturbing way from teachers or scientific animators during the game.

With these considerations in mind we developed a series of three different board games all based on the main idea that the knowledge elements to be learned should not be simply inserted in the game as external elements (as for example occurs in a quiz game) but must be the core around which to build the entire game structure, in particular its rules. These rules must however remain simple and immediate despite the complexity of the inspiring concepts. The game design process took place empirically, through trials and repeated changes, exploiting some prior experience in the creation of "conventional" board games and keeping in mind the above mentioned principles. These board games have been presented and extensively tested in different occasions, in particular in the form of "live games" (on a giant board with human pawns) during three editions of the Festival della Scienza di Genova, the main Italian Science Festival with about 400000 participants in the last edition.

2. Quantum Race

In the microscopic world of atoms and molecules there are anti intuitive rules very different with respect to our classical macroscopic world's ones, rules described by Quantum Mechanics (Muller 2002, Sakurai 2011) instead of classical physics. Quantum Race (Figure 1) is a game developed as a support to introduce and explain fundamental quantum mechanical concepts such as the delocalization of a particle and its "collapse" under an observation, the tunnel effect and the quantum teleportation.

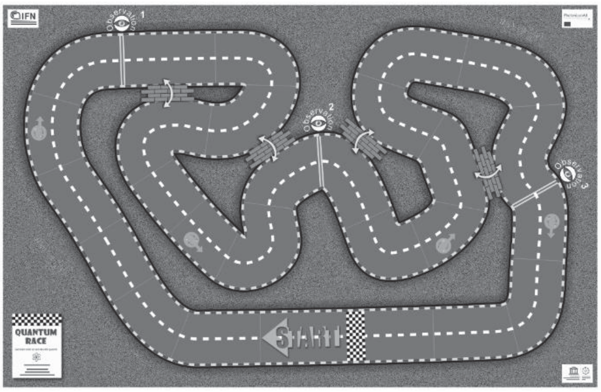

Figure 1: The board of the game Quantum Race

It was presented as a live game (on a board of 70 m^2) during the Festival della Scienza di Genova 2011 (Figure 2) and was played by about 1000 participants, mainly students from 8 to 18 years.

Figure 2: Quantum Race match in live version

It is a typical race-game with cars moving along a track divided in cells. Each car is split in six numbered parts. When all these parts are together in the same cell (for example at the beginning of a match) they represent a “classical” car, but during the game they can be spread along the track with a "grab and seed" rule similar to the classical "mancala" game. In this case it is reproduced the "bizarre" delocalization of a quantum particle. When an observation line is crossed a "collapse" occurs: a dice is thrown and all the pieces of each car return together in the same cell, the cell containing that part with the outcome number. This mimics the effect of the observation on a delocalized quantum particle and the return to the classical condition. Walls between different parts of the track can be crossed thanks to a dice roll, reproducing the tunnel effect. And, in particular positions, two pawns with the same number can be exchanged suggesting the quantum teleportation.

The game is very simple (it has been played with no problems by six year old children) and at the same time amusing and intriguing. Two animators helped the players during the matches using suggestions and analogies to illustrate and explain the principles behind the game. Some quick sample interviews have shown increased interest in the topic and an increased understanding of the basic concepts presented.

3. Lab on a Chip

Lab on a Chip (Figure 3) is a board game developed to explain the immune system and the use of nanotechnologies for its study (Chin 2007).

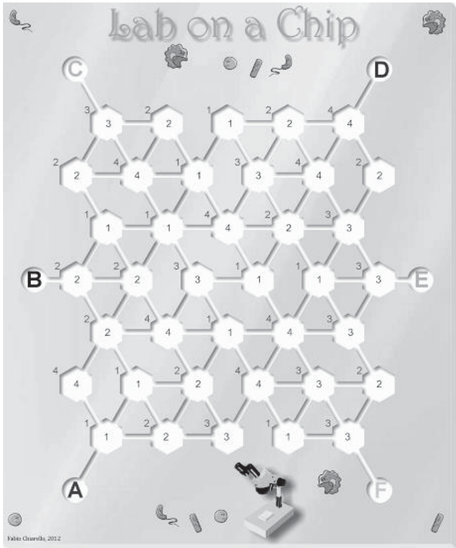

Figure 3: The board of the Lab on a chip game

It has been also presented as a live version (on a 64 m^2 board) during the Festival della Scienza di Genova 2012, and it has been played by about 800 participants, also in this case mainly students from 8 to 18 years (Figure 4).

Figure 4: Lab on a chip match in live version

The giant board reproduces a "lab on a chip", an artificial labyrinth of micro channels where the interaction between immune system macrophages and bacteria is studied. The players take the role of bacteria or macrophages and move in the labyrinth according to simple rules, the first ones with the aim to exit the labyrinth, the others with the aim to catch the bacteria.

Also in this case the matches are accompanied and followed by the suggestions and explanations of two scientific animators, and the observed impact on motivation and understanding of players is good.

4. Time Race

Time Race (Figure 5) is a board game developed to illustrate concepts of Theory of Relativity, in particular Special Relativity and the time dilation effect (Bell 1976). The flow of time is not the same for all observers: an observer moving at very high speed with respect to another one experiences a slowdown in the flow of time as if every second were dilated. This is the so called time dilation described by the Special Relativity, a phenomenon well established and verified but far from our daily experience because perceptible only at speeds close to that of light, at 300 000 km/s.

Figure 5: The board of the Time Race game

The game was presented as a live version (on a 40 m^2 board) at the Festival della Scienza di Genova 2014, and it was played by about 1000 participants, mainly students from 8 to 18 years (Figure 6).

Figure 6: Time Race match in the live version

It is a race game where the track consists of a series of nodes connected by branches. Players can move between connected nodes by a number of steps given by their velocity, a velocity that can be varied at any round. Some branches present speed limits in order to simulate the necessity to take larger paths at higher speeds. Each player has a tachymeter and a personal clock, and during the moving the clock is incremented by a quantity of time depending on the speed (smaller for higher speeds) in order to simulate the time dilation. When a player crosses the finish line his clock is "stopped". At the end all the clocks are compared and used to define the ranking of winners. This mechanism can generate paradoxical situations, for example the first arrived can be the last classified according to his personal clock. These situations are perfect hints to explain and discuss time dilation and relativity, a task performed by two scientific animators that attend the game.

5. Impact

The fast flow of people is a characteristic feature of events like the Festival della Scienza di Genova; it allows a large number of participants but makes difficult a serious evaluation of the game impact. In the first two editions we limited the evaluation to quick sample interviews to participants. For the last game (Time Race) we organized a fast anonymous survey with general information (sex, age, occupation etc.), questions on amusement and appreciation and a self-assessment on the comprehension of the presented topics before and after playing. A complete analysis is in preparation but we can anticipate here some main results. The survey has been completed by 591 participants (294 men and 297 women) with a mean age of 14 years (6 years the youngest, 50 years the oldest). The self-assessment was based on three questions, 1) general knowledge on relativity, 2) difference between special and general relativity, 3) knowledge on the time dilation phenomenon, considered before and after playing, with a possible score from 1 to 5. We obtain an overall average rating on the three questions of 1.93 (before) and 3.18 (after), with a relative increase of 64.7%. In Figure 7 it is reported the histogram relative to this overall result, which points out the good impact of the game.

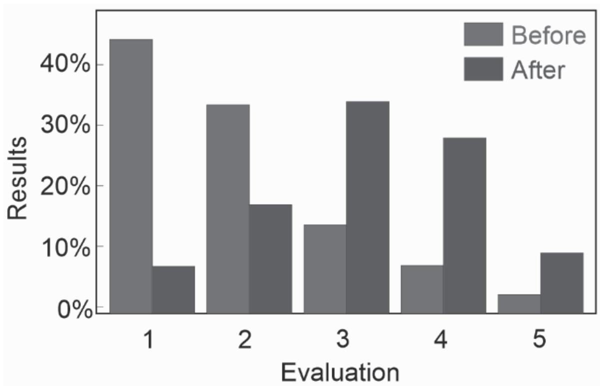

Figure 7: Histogram showing the results of the self-assessment on the themes of Time Race before (blu) and after (red) the match

6. The "Fotonica in Gioco" (photonics game) competition

We are now considering a further step based on the direct involvement of students and general public in the creation of scientific board games. This activity is part of a wider project started at January 2015, the European Photonics4All Project, whose intent is the use of conventional and unconventional media for the awareness of people towards light technologies and photonics. The game-creation activity will be articulated in different tasks in the 2015-2016 period:

- Organization of a competition opened to high school Italian students for the creation of board games related to the themes of light in all the possible aspects (art, culture, energy saving, science, technology, applications etc.). The competition will be held in connection to the "Premio Archimede 2016", the main Italian prize for board games designers.
- Creation of a reference website with information, practical suggestion, tips and tricks on the board game design and on the themes of light (the site is actually online in Italian, www.fotonicaingioco.it).
- Practical laboratories for the introduction to scientific board games creation and development.
- Presentations and conferences in schools, science festivals and games festivals.

All these activities will be carried out in close cooperation with specialists in the field of board game design and expert board game authors.

7. Conclusions

The use of board games entirely built around complex scientific concepts has given good results in the three example here reported. They have shown to be particularly useful in:

- intriguing and motivating players towards the considered issues;
- catching the players interest toward the explanations given by the animators;
- giving examples and analogies which are a fundamental support for these explanations;
- pushing players to a deeper understanding of the essential aspects.

In the next future we will explore the direct involvement of public in the creation of board games of this kind as a learning support for complex scientific arguments.

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Film Education for Primary-School Pupils: Gamification and Interactive Storytelling as an Educational Approach to Raise Awareness of Design Structures in Feature Films

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Abstract: Theoretical Considerations: As the pervasiveness of media usage in the everyday lives of primary school pupils is constantly increasing, supporting the development of media literacy within pupils should be considered as an important educational goal. However, in the real world, the strategy in primary schools seems to be to lock out media usage altogether in order to avoid trouble. The educational techniques behind media literacy, especially in respect to feature films, are very often reduced to providing an interpretational understanding of the story or knowledge about the production process. We argue that even for younger pupils, the reflection of design components and aesthetical structures is also relevant. In a more and more media driven society, processes of identity formation are increasingly attached to individual´s media consumption and his or her social embedding. As Mikos (2000) points out, this process creates the phenomenon that the social relationships of younger generations depend to a high degree on aesthetic criteria. Therefore, aesthetic competence is an important requirement for one's ability to reflect on individual lifestyles. Gamification and Interactive Storytelling as a Pedagogical Concept: s aesthetic reflection is a highly subjective matter, the pedagogical methodology has to focus on creating individual experiences. In order to foster the perception of formal structures and raise awareness of different design qualities, we consider a pragmatic approach for the general structure, which encourages experimental exploration and creative activities (Joas 1988, Kerres/Witt 2002). Additionally, we pursue a gamification concept in the sense of meaningful gamification, as described by Nicholson. He focuses on an understanding of gamification which enables playful participation and is based on the freedom of exploration. This creates the possibility of making meaningful decisions enabled by an informational context, which engages people through social interactions. It is assumed that a playful activity involving film design components as variable structures can enhance an aesthetic and therefore more abstract perception of the presented film plots (see Sutton-Smith 1972, Ohler 1994, Friess 2011). Conceptual Approach for an Interactive Media Environment: The core concept behind the educational application is built upon an interactive storytelling tool, which allows the creation of different variations of the same story. In order to set up a situational context that confronts the pupils with a design problem, we introduce a narrative framework with two children arguing about the way they can design a short film. The narrative context is used to give the pupils the necessary information on design possibilities, allowing them to make decisions in the later experimental part. The application should be embedded in a blended learning situation. This means that a teacher introduces the informational portion, and more importantly, that the pupils can show and discuss their final versions of the short film within the class community. The project is realised at Furtwangen University and supported by the Institute for Media and Communication of Baden-Württemberg. The prototype will be evaluated with primary-school pupils in summer 2015.

Keywords: gamification, interactive storytelling, pragmatic didactics, aesthetic education, film design

1. Media literacy and film education in primary school in Germany – the actual situation

As an actual report on media integration in primary school states, the relevance of media usage in everyday live is not adequately reflected by school teachers in primary schools (LfM 2013).

Based on theoretical reflections on the interdependencies of media consumption and processes of identity construction, we assume that the competence of aesthetical reflection of media design can be a valuable component of media literacy even for younger pupils. In our project, we focus on the ability to differentiate basic structures of narrative composition in film design and reflect their influence on the story and its interpretation.

2. Theoretical reflections

2.1 The value of aesthetic education

According to Mikos (2000), mass media, from the fifties till date - has television as a central player which gives us the platform to find our way into society. It gives us a variety of possible life paths, role models and helps us to reflect our attitudes to norms and values. Therefore media consumption is gaining a central role for our social integration. As a consequence of increasing detachment and seclusiveness of mediated communication, community building is less built on common interests or qualities (in real life), but more and more on internal structures of the communication process itself (see also Krotz 1995). Aesthetical dimensions then build the crucial element of the shared media experiences and mediated lifestyle concepts. (see Mikos 2000) Taking this into account, it seems helpful to foster aesthetical education within the field of media literacy.

2.2 Gamification and interactive storytelling

In pragmatic Philosophy, the capacity to make experiences and reflect them, play a central role for social interaction and human cognition (see Joas 1988). As Joas states, action is not seen as goal driven process with a linear course in the first place but as process, which always includes some kind of ambiguity and therefore embeds the creativity of free choice. Conveying these thoughts to didactic concepts, especially E-learning, it focuses on experience making in learning environments. As Kerres/Witt (2002), in their reflection on pragmatic didactics claim, experience has to come before cognition, but the experience has to be meaningful for the learners.

They state three main components of a pragmatic approach for e-Learning environments: 1. content component which lays ground for cognitive and also emotional activities in learning situations, 2. constructive component which allows the user to undergo learning activities leading to material results, and 3. communicative component which structures the communicative exchange among the learners and between learners and teachers (Kerres/Witt 2002).

As Joas (1988) points out the pragmatic understanding of assumed freedom in action allows playful variations. We refer to the concept of play as a mental framework but not as an activity. Ohler and Nielding (2001), explicate a theory of playful cognition which in contradiction to narrative concepts, enhances human beings to develop variations (whereas narrative framework focuses on the one most probable causality (see Friess 2010)). Based on these thoughts, we assume that experimenting with film design components within a given situation, enhance the possibility to step beyond the primary story level and foster the cognition of design structures on a more abstract level. Therefore, our concept evolves into a gamification of learning, but with an understanding of gamification as described by Nicholson (2015). Meaningful gamification has to be built upon the following components: exploration within boundaries, possibility of choice, informational background, and contentbased engagement and reflection of experiences. (Nicholson 2015)

3. Conceptual approach for an interactive media environment

3.1 General concept reflection

The learning environment consists of a learning module and an experimental module. The learning module introduces a narrative framework and provides exemplary knowledge on film design as basis for the experimental module. The experimental module allows the pupils to combine different film design components within an interactive short movie.

With reference to Nicholson (2015) our concept provides the informational background on film design within the content of the learning module. The explorative part is realised with the interactive-story environment in the second module. In order to enable a situated decision making process we embed the informational content in a narrative framework, which reflects the decision process of film design. Emma and Paul are two children arguing about different ways to create their short movie and discuss this by demonstrating the alternatives with short movie scenes.

Besides the aspect of playful perception and gamification exemplified above, our concept also follows the pragmatic approach of Kerres/Witt explained above. The learning module builds the content component and set a basis for participation by cognitive comprehension and emotional involvement. The constructive component can be found in the experimental module, which lays ground for an intrinsic motivated learning by experience. The communicative component is integrated into a blended learning situation during the class. A vivid exchange is aspired for presenting and discussing the individual results in class.

3.2 Learning objectives: Aesthetical awareness of basic components of film design

Based on cognitive film theory of Edward Branigan (1998) as well as the anthropological perspective of Murray Smith (1995) we see three core components for film design: the character as human agent, the narration as structural link between story and recipient, and the audiovisual design of the movie as linking layer for the narrative and aesthetic experience.

Within the smallscaled student project, we do not intend to reach an extensive teaching of film design, but to teach an exemplary awareness of the design possibilities by demonstrating opposing design options in each of the three basic design categories.

Following Joas´ interrelation of pragmatism and play as a freedom of choice, we refer to the concept of play as a mental framework and not primary as an activity. We assume that the interactive story-telling environment allows for a playful perception and therefore more structural perception of the provided variations.

Aesthetic experience is understood, with reference to Jauß´ (1997) aesthetic theory as a productive and creative process. To be able to develop variations, people have to transfer phenomenological perception in more abstract models. Therefore, we assume an interaction between playful activities within a media environment and the possibility to foster the awareness for aesthetic structures.

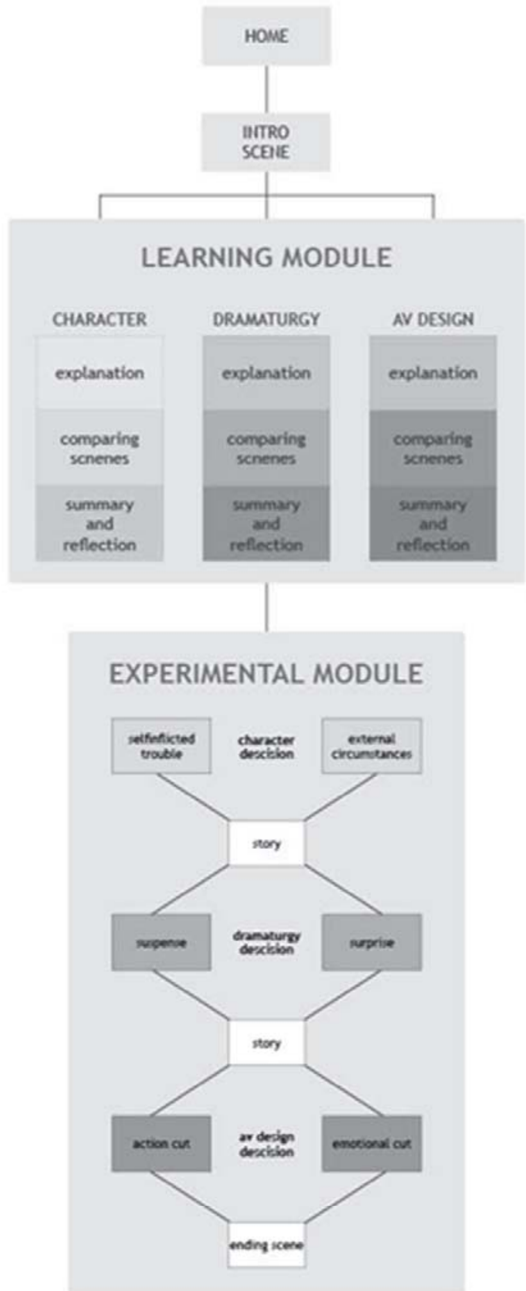

Figure 1: Conceptual framework of the learning environment

3.3 The propaedeutic learning module

The learning module consists of three chapters: Character, audio-visual design and dramaturgy. An introduction sequence establishes a conflict, in order to set up a situational context that confronts the pupils with a design problem. The young protagonists Emma and Paul want to shoot a film based on a fairy tale and are discussing about different design options. Based on the discussion of Emma and Paul, some fundamental terms of film design are taught. After that, the protagonists present each of their favoured design options as short film sequences, showing exemplary scenes of the fairy tale in oppositional designs.

Figure 2: Fairy tale scene within the learning module

3.4 The interactive story-module as experimental part

The film tells the story of a group of girls who apply for a dance competition. Julian, who has financial problems, joins the group. Right before the group begins to shoot the necessary video, Julian steals Laura´s bag. Chasing him, Laura slips and falls. Julian gets a bad conscience and comes to Laura´s help. Then the group finally finishes the video and succeeds in the contest.

Figure 3: Clique meeting scene within the experimental module

At the beginning of the experimental part, students decide between two opposed main characters: A cool action hero or a more sensible protagonist. Right before the climax, students decide whether they want to make a suspenseful or a surprising scene. Before the chasing scene starts, the students are able to decide between different audio-visual designs, an action oriented or a more empathetic film style.

The learning environment is designed for an embedded use in the class. The teacher introduces the learning and the pupils can present and discuss their results in the class. It is expected, that the reflection on design components is fostered by comparing the different versions.

4. In conclusion

The project aims at teaching a basic understanding on film design components basing on the experience making within an experimental learning environment. We assume, that experimental and playful decisions enhance a more structural and aesthetical perception of a given narrative short film and therefore allows the pupils to reflect on design components.

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A Teacher Survey to Identify Solutions That Facilitate GBL Design for Engagement

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Abstract: Game-based learning (GBL) remains important for engagement and learning. It is about much more than simply learning with games. GBL involves several steps, approaches, elements and features in gaming that lead to and enhance engagement and leaning. The accelerating pace of gaming and digital technology, along with increasing pressure on teachers to improve pupils' performance and achievement, means there is a need to search for innovative approaches to GBL that will engage pupils with learning. By "engagement" we mean the capacity to create and sustain a momentum of continuous learning so that pupils become self-directed learners. However, only a few surveys explore the connections between approaches, strategies, resources, teaching and learning in the context of designing and using GBL to increase engagement. These connections may be understood as "learning experiences" and "conditions" in classroom learning environments. Therefore, the attempt to harness and maximise teaching and learning approaches, strategies and resources is at the centre of GBL research and initiatives. Thus, we designed and administered a teacher questionnaire as part of design-based research (DBR). The purpose of the questionnaire was to gain insight into teachers' instructional practices, give teachers the opportunity to share their teaching experiences, and keep a broad and open understanding of teachers' experiences, including their positive and negative feelings and thoughts. The findings presented in this paper evaluate increasingly varied materials, resources and solutions for enhancing learning within primary and post-primary schools. This survey also aimed to gauge teachers' enthusiasm for using a game-based approach to designing classroom activities and for extended learning, towards our effort to introduce and enhance GBL approaches. The survey results may improve our understanding of teachers' concerns, requirements and GBL suitability in relation to introducing and using games as a teaching and learning method in the classroom and for independent and extended learning.

Keywords: engagement, school, learning, design, performance support

1. Introduction

Until recently, research (Clark et al 2013; Connolly et al, 2012; Wastiau et al, 2009; Young et al., 2012) has shown that the dominant strategy for game-based learning (GBL) in primary education is the digital game-based approach. Surveys on teaching with technology and digital games in classrooms have been carried out relatively frequently (Pressey, 2013). People widely associate GBL with the use of digital gaming and technologies for learning. Within that, they connect GBL with commercial off-the-shelf (COTS) digital games, massively multiplayer online role-playing games (MMORPGs) and virtual reality (VR) games. The prevalence of GBL across a broad range of approaches demonstrates that it is a high-tech and complex approach that engages pupils in playing games and using technology; however, when perceived in this way it perhaps does not always encourage learning (Downey et al 2007; Wastiau et al 2009).

To move beyond this perception of GBL, we need to reinvent GBL approaches so they provide opportunities for engaged learning. We must look beyond a singular method of GBL. If GBL is to be promoted in classroom settings, it is essential that the gaming is designed to facilitate engagement (Whitton, 2011). Engagement, according to Swan (2003), is about creating meaningful, interactive and challenging learning experiences that involve enthusiastic, confident and strategic learners to achieve their desired goals. Jantke (2010) suggests that what is crucial in GBL design for engagement is the extent to which GBL can promote learning in a way that sustains players' interest. Likewise, it is important that players are able to make sense of their experiences in terms of what they already know and modify their understanding as they encounter new ideas and experiences (Plowman et al, 2010) in the gameplay. Thus, this study discusses a range of strategies, resources and approaches in classroom settings to support learning and create opportunities for the pupils to be engaged and learn.

2. Method

This survey was the first step towards answering the research question in the chosen DBR approach. The aim was to identify solutions that will help pupils become more engaged with learning the curriculum content. The research question is: what approaches, strategies and resources can teachers use to engage pupils in learning curriculum content? A web-based questionnaire was administered through email invitations. Paper-based questionnaires were distributed to schools that had allowed access to their teachers. The data was analysed using a software package (SPSS) for descriptive statistics.

3. Results

To date, 18 questionnaires have been completed (eight online, and ten paper-based). A limitation of the results is that the response rate was extremely low. However, we found that the findings were relatively consistent with those of the pilot study (which was based on five responses from personal and professional contacts).

3.1 Key findings

The key findings were as follows:

- **Teaching and learning resources:** The frequent use of online resources and visual aids suggests that the use of extended learning materials is continuing to increase and that teachers are seeking convenient resources to supplement their other learning materials in order to enhance learning.
- **Teaching and learning approaches:** Although most teachers said they were familiar with well-known teaching and learning approaches, they were more likely to use problem-based, inquiry-based, project-based or collaborative-based learning.
- **Teaching and learning strategies:** The use of multiple level instructional materials, variety of activities and resources, and questions to trigger learning activity are the top three strategies to enhance learning.
- **Perceptions of GBL as a teaching and learning approach:** Teachers did not reject GBL or indicate that they had negative perceptions of it. However, they had concerns about using GBL as an approach to teaching and learning.

3.2 Teachers' characteristics and subjects taught

Ten (55.5%) respondents were females and eight (35.5%) were males. Six (33.3%), had been teaching for between six and ten years. Four had been teaching for more than 15 years, three for between 11 and 15 years, four for between three and five years and one for just one year. This suggests that there is a mixture of experience among these respondents. Most (10) teach all subjects in the primary curriculum, five teach a variety of subjects, and two teach specific subjects (i.e., computer science to 13- and 14-year-olds; PE to 8- to 14-year-olds).

3.3 Use of resources in the classroom

Most teachers (11) stated that they used visual aids (e.g., PowerPoint presentations), online resources and schoolbooks on a daily basis. Games and stories or literature were used at least once a week by most teachers (11). One teacher had never used simulations or animations.

3.4 Teaching and learning approaches and strategies

Most teachers were familiar with most of the teaching and learning approaches listed in the questionnaire. One teacher was unfamiliar with case studies. All teachers stated that they were likely to use problem-based, inquiry-based, project-based and collaborative-based learning in the classroom. The teaching and learning strategies that all teachers said they were likely to use in their classroom included using multiple levels of instructional materials, a variety of activities and resources and asking questions to trigger learning activities.

3.5 Perceptions of GBL

Teachers had mixed opinions on the use of a game-based approach to teaching. Most thought that using games to teach language, maths and science could be effective. They also mentioned that games could be used to enrich learning, introduce topic areas and provide opportunities to practise skills. Most thought that games could be more effective if they were linked to the curriculum objectives and were suited to pupils' abilities. Lack of resources and suitable game content, and time constraints were among teachers' concerns about implementing GBL. Most teachers indicated that there are issues with using games in the classroom. Some of these issues were gaming elements (e.g., competition) and some were individual factors (e.g., shy pupils). However, teachers perceived that a game-based approach was likely to be interesting, enjoyable and competitive for pupils.

4. Discussion

As the results suggested, handling vast topic areas and pupils at multiple levels of ability is a continuing challenge for teachers and has always resulted in a massive workload for them. Learning can take place in different kinds of settings using multiple strategies and resources. Teachers know that these resources, approaches and strategies are necessary to engage pupils and improve their performance. However, it is difficult to know which of these solutions is most effective.

4.1 Strategies could be used to engage pupils

The results indicated that the best way to engage pupils today is to give them access to a variety and multiple levels of materials and activities, and questions that trigger the pupils' curiosity and activate their background knowledge of a topic. From this viewpoint, an engaging learning environment begins with pupils having access to a multilevel and range of resources (e.g., online materials and visual aids) and activities that include quizzes and play opportunities (Irish National Teachers' Organization, 2007). Hence, acknowledging pupils' preferences and their abilities could be the essence of GBL design for engagement.

4.2 GBL as a teaching and learning approach

The game-based approach was not as widely known as problem-based, inquiry-based, project-based and collaborative-based approaches to learning. However, feedback from teachers suggests that GBL approaches have the potential to enhance learning in particular subjects (e.g., language, maths and science) in schools. One of the biggest concerns in facilitating GBL in the classroom was about how to engage different types of pupils within a game. Therefore, the gaming approach must also consider what types of activities will engage pupils with different personalities. As expressed in the survey, some pupils tend to be very competitive and overshadow the less competitive ones. If overlooked, this could represent a negative aspect of GBL.

5. In conclusion

The results provide a context for obtaining teachers' perspectives on teaching and learning and their experiences of and concerns about GBL as an approach to teaching and learning. Teachers have important roles to play in creating an engaging environment for effective GBL. While teachers continue to provide practical instructional options in classroom settings, they must also move toward solutions that focus more directly on pupils' skills and knowledge, their technological needs and the limitations to overcoming the challenges of learning complex curriculum content. Therefore, for GBL approaches to encourage engaged learning they must be able to provide opportunities for pupils to engage in learning within a flow of different difficulty levels, materials and activities as they play.

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Applying Memory Theory in Game Design (Case Study)

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Abstract: This article reflects upon the design process of the game Tella, an application for tablet computers, designed for children with special needs in the lowest grades at school. The game facilitates learning of mathematics through playing and exploring. The tablet allows the visual and interaction design to work together with sound and movement, in ways that differs from traditional learning material and classroom practices, supplementing both these arenas of learning. Several different pedagogical principles are applied in the game. This article will focus on the concept of *implicit memory / priming*: Elements (e.g. the number line) are introduced visually at an early stage, but not put into practical use until later in the game. Priming is a concept from the field of memory research, not a pedagogical principle or a learning theory as such, but in connection with designing games this concept is applicable and very helpful. Further on this article reflects upon the balance between game logic and learning logic, when designing serious games. There are contradictions that need to be negotiated if an application should serve as an e-learning resource as well as an enjoyable game. The article suggests a way of developing educational games. The design of the game started by having experienced teachers sit down and work with designers and game programmers. The result incorporate theories and principles of learning, memory, game design and instructional design.

Keywords: serious games, learning, priming, design

1. This is TELLA

Tella is a game of mathematics, designed for children with learning disabilities in the lowest grades at school, also aiming at normally functioning children of lower age, from three years on. The visual and instructional design is made to be appealing and motivating, to encourage children to play.

When planning the design we had a list of challenges:

- Teach mathematics, helping children build basic understanding of some crucial concepts, connections and operations.
- Facilitate basic digital competence.
- Make maths fun and appealing for children with learning disabilities (motivation).
- Make it possible for these children to feel mastery on a field where they usually have little success.
- Facilitate individualized instruction in groups (classes) so that children may work/play on different learning levels without leaving their class, which will have a social integrative effect.
- Be a tool for teachers who want variation of methods in their teaching.
- Be a tool with connections to other learning material (like text books) and physical/tactical/motoric learning situations.

We do emphasize that digital learning can not fully replace traditional types of learning in mathematics: In order to learn children need to apply most senses. Tactical and motoric stimulation are crucial, and such activities are not afforded adequately by a screen alone.

Tella consists of several modules (levels) with tasks to be completed in a predefined order. The structure of the game and the learning has been carefully planned with a slow progression, each level building on the previous. The teacher may customize the game for each pupil individually by making tasks invisible. Thus it is possible for a child to achieve mastery even if he does not have access to all tasks.

The game begins with building awareness of size and position/order/ranking. Then follow counting, figures, numbers and quantities up to nine. The number line is gradually introduced. (Number line is important to understand the relationship between numbers and ranking.) The final levels of the game offer tasks with simple equations.

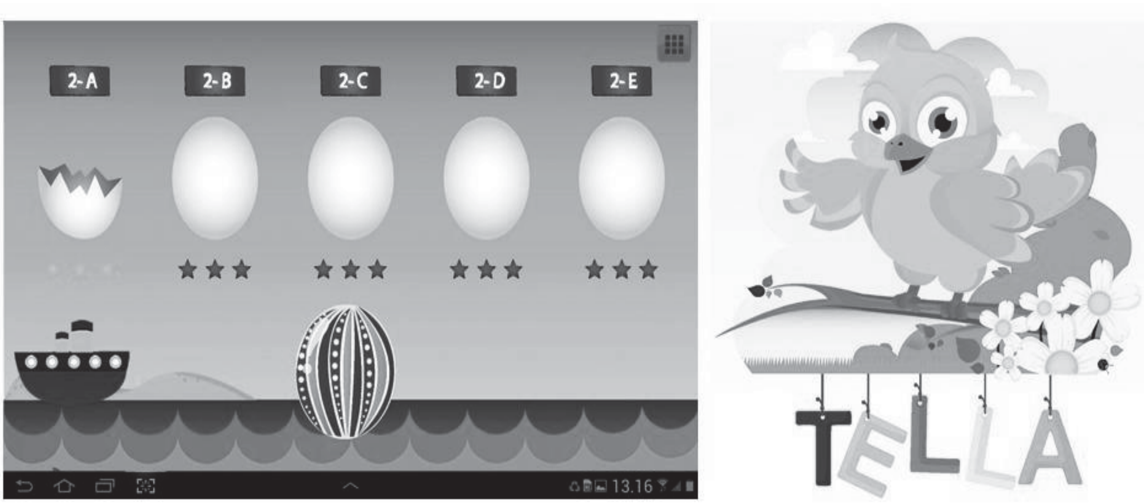

Figure 1: The yellow bird is the helper, and tasks are presented as eggs

Recommended playing time is maximum 30 minutes at a time, and teachers are advised to elaborate the different themes of the game in "real world" surroundings, motivating the children to practice counting and playing with numbers in an everyday context.

2. Implicit memory and priming

When designing Tella we have applied principles of memory and learning. Among those *implicit memory/priming*. Implicit memory, as opposed to explicit memory, "occurs when memory influences our behavior without conscious awareness" (Passer & Smith 2011, p 266). This relates to the process of priming, where "exposure to a stimulus influences (i.e., primes) how you subsequently respond to that same or another stimulus." (Passer & Smith 2011, p 178). By introducing phenomena visually without problematizing them, the game prepares the child for the conscious handling, which will be demanded later.

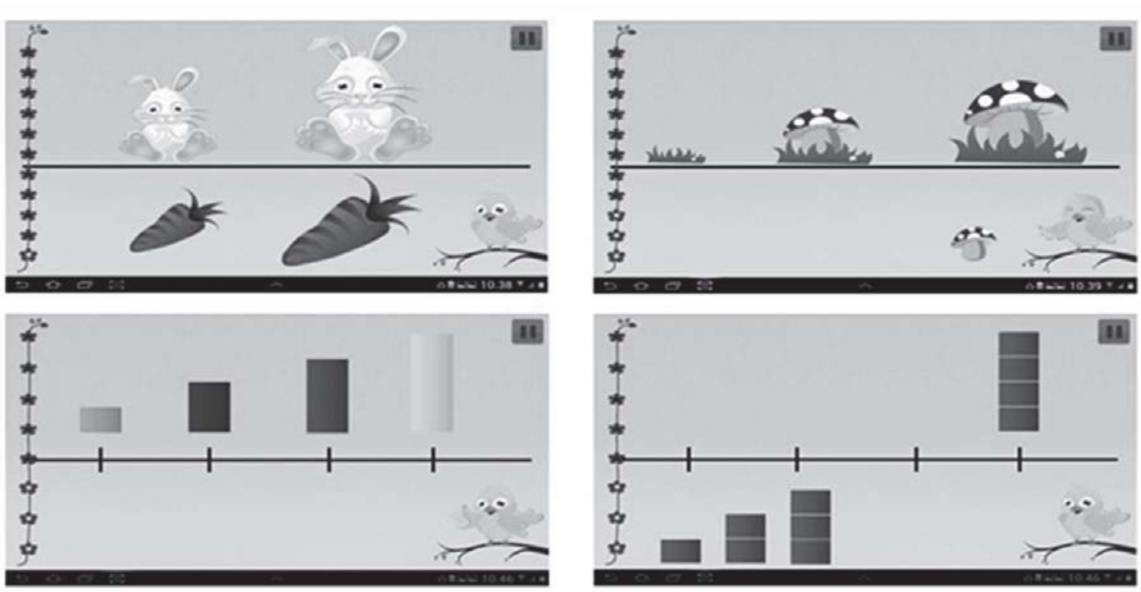

Figure 2: The child learns to range objects according to size. The smallest object is always to the left, to prepare for the understanding of number lines

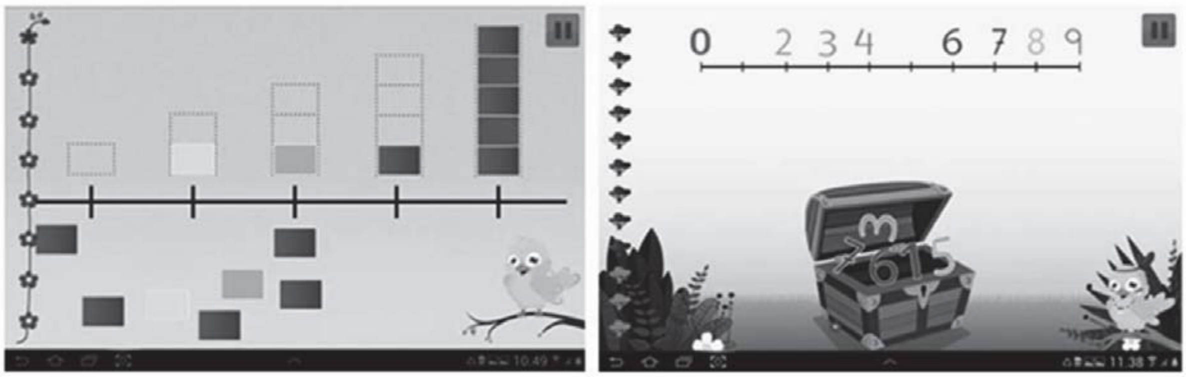

Figure 3: Building quantities to prepare for the understanding of numbers, then working/playing with the number line

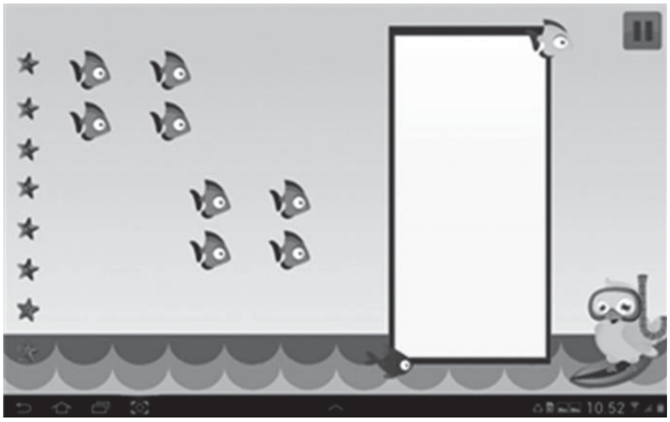

Figure 4: The objects that have to be counted are shown in patterns/quantities. Note how the eight fish are divided into four plus four, preparing the child to later addition

3. Theories of learning

The game Tella is also drawing on *instant feedback and reward*. This is based on classical behaviourism and stimulus-response models, and is a common base for a lot of small main stream games as well as serious (pedagogical) games. Having given an answer to a question or a task, the child gets immediate response by means of sound and the bird's approval. There is also a "not so immediate" response as the player's collection of stars increases. The stimulus-response theory and the concept of implicit memory also shed light on how children "automate" some patterns of behaviour. *Automaticity* of certain tasks are vital when performing mathematical tasks - one cannot contemplate all the logic behind every step in a mathematical task, but has to rely largely on an "automated" set of basic skills (Hasselbring, 1988).

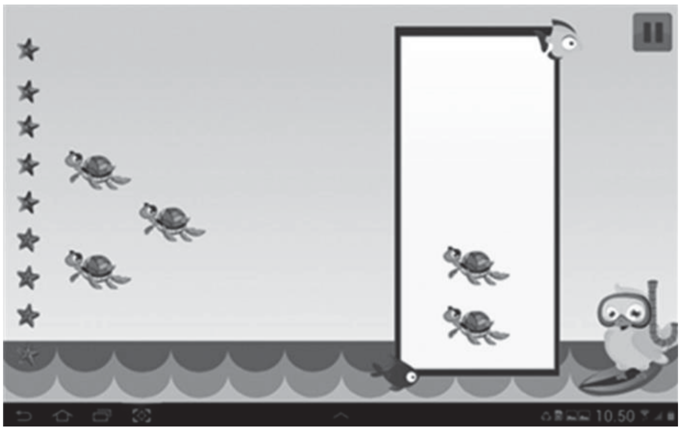

Figure 5: Automation of counting is learned by small children long before they are capable of understanding quantities and numbers. The bird is counting out loud together with the child here (auditive input)

The game may be regarded as a partner to the learning child. Therefore it becomes important how features of different game mechanics may influence on the individual's reasoning (Arnseth, 2006). This makes some aspects of socio-cultural learning theory relevant, where learning is understood as a close interplay between human actors and artefacts. The introduction of new concepts, in a specific order, can here be seen in light of the *theory of "Zone of Proximal Development"* (Vygotsky, 1930). Vygotsky's theories were developed from observing how small children expand their capacities when interacting with others. Vygotsky defined the "Zone of Proximal Development" as the difference between the level that the child can develop by independent problem solving and their potential level of development. Children can reach higher levels when collaborating with others, where the Zone of Proximal Development can be seen as a bridge between the individual learner and their cultural environment (Erstad, 2001). As computer games are among the significant artefacts in the culture surrounding many children, and moderate gaming in may give a positive contribution to the development of children's skills and knowledge (Przybylski, 2014).

4. Gaming logic versus pedagogical logic

A significant challenge is to design games that give the players proper and interesting challenges (Egenfeldt-Nielsen, 2011). This is a difficult design issue in its own right, which becomes even more complex when taking wanted learning outcomes into account.

In game design it is considered vital to keep the player in "the zone" where he experiences "flow". The concept of flow is used to explain how joy or happiness can emerge from activities where the player is experiencing total involvement (Csikzentmihalyi 1992, 71). This concerns the level of complexity and difficulty of the tasks being sufficient to keep the player engaged. We are not talking about "zone " in Vygotsky's sense, but the two concepts are somewhat related. A wanted outcome in game design is to bring the player into short periods of frustration, where he struggles to solve the problems presented to him, then provide the feeling of accomplishment, and thereby keep up the player's engagement. With the helper always present within the game, and a teacher at hand, pupils with difficulties can be kept in this dual zone, where they are constantly challenged and rewarded by mastering series of different tasks.

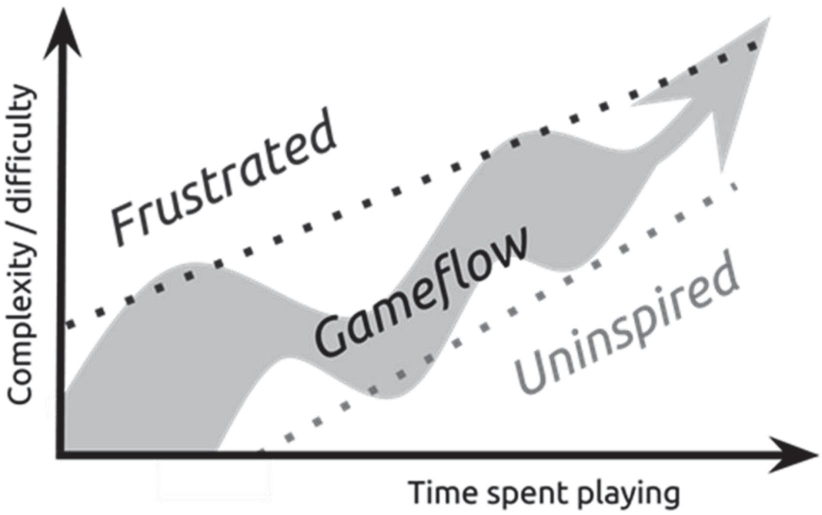

Figure 6: The "zone", between frustration and activities that the player find uninspiring, where the players are in the "flow"

Players are of course different, and it is hardly possible to design tasks that give all users the same level of engagement. It is not possible to design for a specific level of difficulty that also keep every player engaged at all times. This becomes even more difficult when designing a game for pupils with special needs. Many of these players may have problems concentrating, and easily become distracted. If they become frustrated or uninspired they tend to look for something else to do. Thus it becomes important to keep these players within the engaged-zone as much as possible during their gaming time.

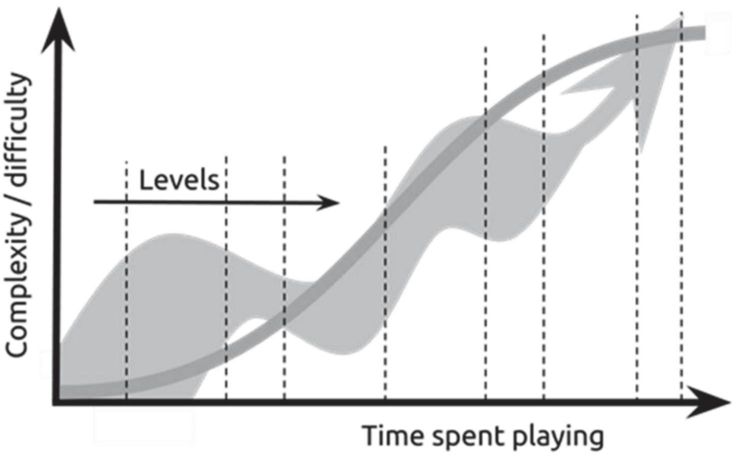

Figure 7: A game for users with special needs to keep the technical challenges at an almost even level throughout the game. The orange line indicated the level of mathematical complexity, which increases throughout the game with each level. The complexity of the game mechanics do, however, not increase in a similar way. The tasks do become somewhat more complex, but most are managed with relatively simple point, drag and drop

5. Conclusions and further work

We have discussed some theoretical approaches, which were present in the process designing Tella. However, the theoretical approach was not the starting point when the design was initially planned. Experienced teachers' knowledge was used in interplay with experience from game designers, instructional - and visual designers. The result has become a game that may not fulfill every game design rule, but the result is grounded in knowledge about learning and memory.

Our preliminary conclusions draws on experiences from field testing and user feedback. This emphasizes the importance of collaboration between teachers, designers and programmers. Each of these collaborators bring in expertise crucial to a successful game: It is necessary to know what is going on in a classroom, how children learn and play, how visual elements can be explanatory and carry meaning and motivation, how games are structured to make the player want to go on pursuing a goal, what affordances and limits are set by technical devices, and so on.

The work with Tella demonstrates how learning principles can be applied to game design. Further work and research will seek to provide a more thorough analysis of the game and how it is used. This will include field testing to investigate how the game is used, and to what extent the game is being regarded as useful in real educational contexts. This testing will include observation, structured interviews with teachers and group interviews with children.

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MMORPGs in the Educational Process: Using a CSCL Script to Assess Learning

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Abstract: Since the research in video gaming has given the first long-term results, new research fields emerged to exploit video games in the educational process. With a considerable fan crowd and the game industry spending more and more every year in Massive Multiplayer Online Role Playing Games (MMORPGs) development, the exploitation of MMORPGs in the educational process became a promising prospect. This study is an attempt to bridge MMOPRGs and the educational process, taking into account social, emotional and cognitional aspects. Based on a composite educational model combining collaborative learning, role-playing and problem solving, a Computer-Supported Collaborative Learning (CSCL) script was designed, converting an educational curriculum from the 6th grade of elementary school, into a Problem Based Learning (PBL) scenario embedded in a quest in a MMORPG called "Neverwinter". In order to embed the scenario in the game, the activities were designed and implemented in a customized and secure environment created in Neverwinter for the needs of the study. Using the quest creating system that the game provides, three independent quests were created, one for every cognitive field, for the students to complete in groups of four members. During the educational scenario, a role was assigned to each student based on the multiple intelligence theory and the person's dynamic. The main goal of the scenario was for the students to acquire psychomotor, social and meta-cognitive skills, and enhance knowledge and emotional attachment to the cognitive fields of history, physics and social & civic studies. For the purposes of the scenario, the players first had to study interactive educational content that was designed and provided by a learning management system, and then had to use the game to complete educational activities based on problem based learning techniques. During the educational activities the students, depending on their roles, had to solve mysteries, find clues and answer questions while interacting with non-playable characters (NPCs). The results of the study showed an increased performance on every tested cognitive field, increased engagement and a considerable decrease of violent behaviour between members. These results suggest the need of longitudinal studies in the field of educational games and especially in the use of MMORPGs in the educational process and the development of educational MMORPGs that would be based on modern pedagogies that would be accessible even by students with disabilities or in remote locations.

Keywords: MMORPG, role-playing game, problem solving, collaborative learning, PBL, CSCL Script, multiple intelligences, educational psychology, Bloom taxonomy, game based learning

1. Introduction

A research that was conducted in the USA in 2011 from NPD Groups Inc. indicates that, 91% of children from 2 to 17 years old are involved in some sort of video gaming (Riley, 2011). According to the American Psychological Association, after years of research, avocation with video games works beneficially on the person's health, as well as its social and learning skills, due to the strengthening of memory, cognitive abilities, 3D space perception, reasoning and observation. In addition video games enhance creativity and develop problem solving skills. On the other hand, facing a failure in a game's mission has been proved effective in establishing emotional resilience, while social gaming reinforces socialization through a framework of a worldwide virtual society (Nauert, 2013). This study is focused on a specific video game category, which emerged during the 90's, known as MMORPGs (Massive Multiplayer Online Role-Playing Games) and is about collaborative online role playing games of massive scale. A triennial global research, of 30.000 MMORPGs' gamers, conducted by Nick Yee under the authority of Stanford University (Yee, 2006), presented results of equal age distribution with a balanced personal, professional and social life on the participants, abolishing concerns and highlighting the possibility of lifelong learning. Although many studies have highlighted the pedagogical possibilities of computer games and especially MMOPRGs (MacKay, 2013), an integrated pedagogy has not been developed yet to accompany such a tool, putting the development of an educational MMORPG in risk of failure.

2. Theoretical background

So in order to utilize the advantages of MMORPGs in the educational process, a conceptual framework is required, with an educational framework to be defined, explicit educational goals and a fitting teaching model. In this conceptual framework, the structural theories are selected after an analysis and classification of the educational characteristics of MMORPGs in the relevant theories of educational psychology. The classification detects characteristics from three teaching model, which are the teaching model of Problem Solving, of Collaborative Learning - STAD and the Role-Playing Game model (Eggen & Kauchak, 2012). Some other educational characteristics detected are also, the multiple intelligences theory of Howard Gardner, that allows participants to use their special intelligence to succeed a goal (Roblyer, 2008), a sophisticated motivation system based on Skinner's positive reinforcement and attenuation, and Bandura's imitation theory (Elliott, et al., 2008). Evolutionary to the behavioural motivation system, the MMORPGs can be the means for the adoption of a universally accepted morality, based on a global culture, developing a multicultural society that doesn't recognize racial and social differences.

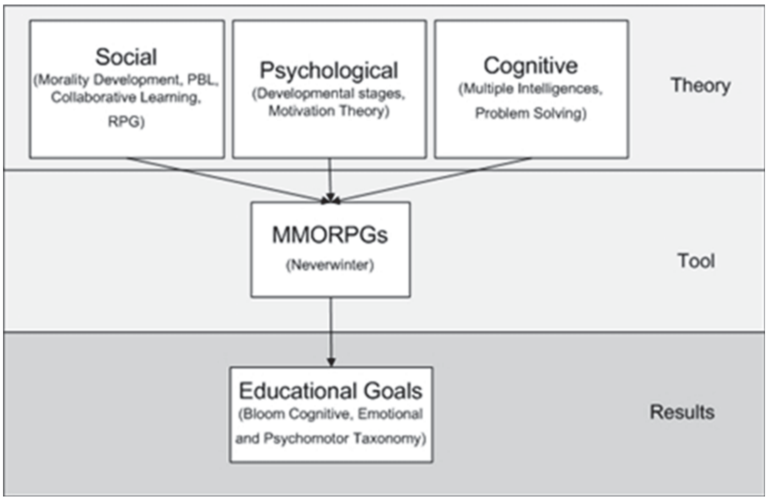

Figure 1: The conceptual framework

A fitting educational framework, due to the problem solving model that is exploited in MMORPGs, is PBL (Problem-Based Learning), which is a complex, learner-centered, pedagogy, where learning occurs during the problem solving process. Based on self-directed learning, learners individually and/or collectively have responsibility for the learning that occurs, and with self-reflection they adapt their learning strategy. The use of technology to develop multimedia material to support the PBL is named VPBL (Virtual PBL), and it is ideal for application on people with learning difficulties, as it covers a greater range of intelligences (Hung, et al., 2010).

3. Methodology

The present scenario aims to educate students of sixth grade in courses of Physics, History and Social Studies. More specifically, we selected the topics of, energy sources and their origins, family types and values, and finally the Renaissance and the Enlightenment. These courses have been selected to investigate, the possibility of learning in the science, social and theoretical fields and the efficiency of 12 years old students, using a virtual environment. The virtual environment that will be used for the application, is the MMORPG named Neverwinter of Perfect World Entertainment, which is based on the fantasy world of Dungeons & Dragons and provides a series of epic stories and quests. Players are able to choose between 7 classes and 12 races, to shape the character with which they will participate in the story.

3.1 Complex teaching model

Having PBL as educational framework, we need to structure a teaching model, based on the three aforementioned models, to proceed. The following table presents the complex teaching model aiming to the social, emotional and cognitive development of the individual, combined with the development of new skills or the improvement of the those already acquired, using MMORPG as a tool to support the educational process and as an supplementary learning environment.

Table 1: The phases of the complex teaching model created for the utilization of MMORPGs

Category	N.	Complex Teaching Model	CL - STAD	PS	RPG
Preparation	1	Problem Introduction	Introduction	Problem Understanding	Define Objectives
	2	Team Formation	Group Transition	Describe Barriers	Choose Context and Roles

Category	N.	Complex Teaching Model	CL - STAD	PS	RPG
Performance	3	Team Study	Team Study	Identify Solutions	Student Preparation
	4	Team Play		Try out a Solution	Role Play
Valuation	5	Review	Evaluation	Evaluate Results	Concluding Discussion
	6	Assessment	Team Recognition		Assessment

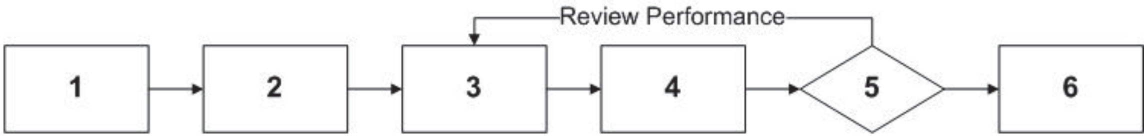

Figure 2: Teaching model's phase flow

During the development of the teaching model, arose the awareness of a potential classification based on the knowledge acquired. This classification is very important for a newly developed teaching model, as it clarifies the content and processes of both the phases that constitute them, and their activities.

- Preparation: Procedural knowledge of lifelong self- directed learning in a group.
- Performance: Exploration of conceptual knowledge through a productive group process.
- Valuation: Enhancing critical thinking and resilience.

3.2 CSCL macro-script

At this point, the number of individuals per group, the roles, the way of their distribution and their responsibilities, activities, the estimated duration and the tools that support them are defined.

Table 2: Activities are developed for each phase of the teaching model.

Phases	Interaction	Activity	Tools	Duration
Problem Introduction	Classroom	System presentation	Presentation system	20' (once)
	Team (4 members)	Educ. context presentation		15'
Team Formation	Team (4 members)	Role assignment	MMORPG	20' (once)
Team Study	Team (4 members)	Problem identification and organization of possible solutions in the digital world	MMORPG, book, e-notes	10'
Team Play	Team (4 members)	Complete mission in the digital world	MMORPG	10'
Review	Classroom	Discussion - Evaluation	-	5'
Assessment		Award badges	Badges system	5'

The reason for having these groups consist of an even number of four members, is the development of Quad triality. For this reason, the available roles will be three, in order to encourage the development of trinitarian relations and projections (Namka, 2004).

Table 3: Role description

Amount	Roles	Description
1	Leader	He coordinates the team and the work of its members.
1	Scout	Identifies the problem in the game.
2	Councilor	Propose solutions to the problem.

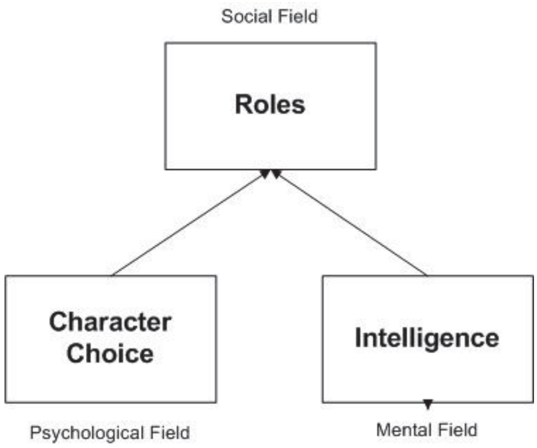

Figure 3: Role assignment

3.3 Scaffolding content

In the following section, by utilizing the educational content of the courses; textbooks, notes, interactive text and images are created and provided to the students as an auxiliary material from the tutor, for scaffolding support to the problem solving process.

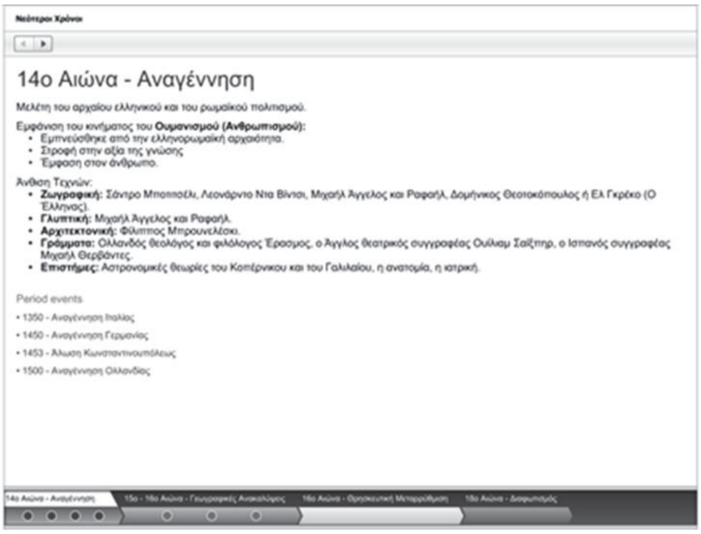

Figure 4: Historical timeline for Renaissance

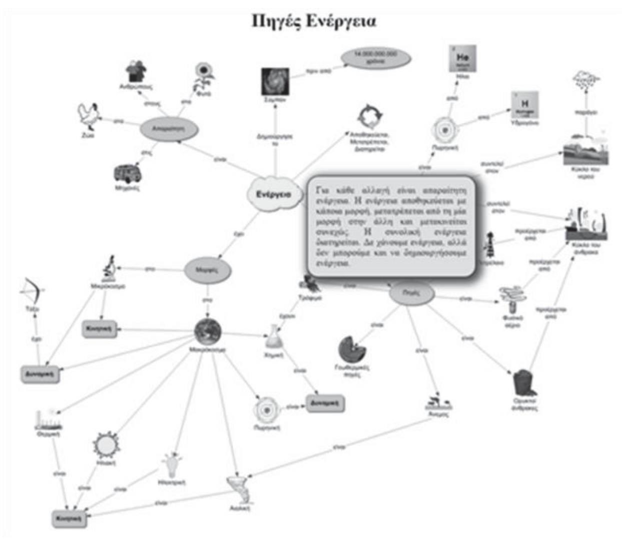

Figure 5: Interactive mind-map on physic's semantics

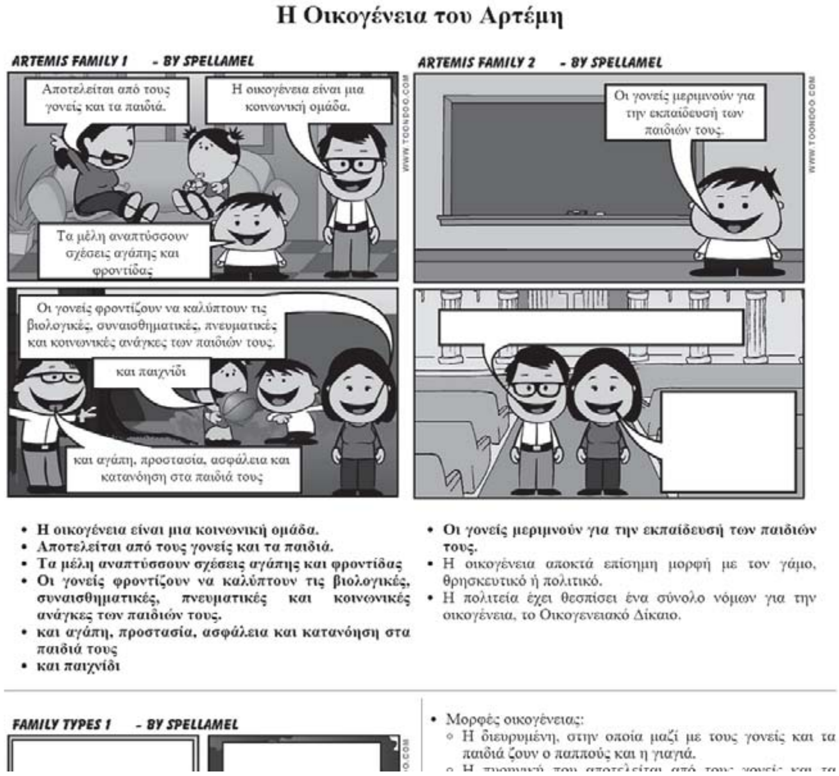

Figure 6: Interactive comic on family values

The scaffolding material was created with tools such as iSpring Kinetics, inspiration, ToonDoos and the languages HTML, CSS and JavaScript in order to support students with different strong intelligence, beyond linguistic.

3.4 CSCL micro-script

During the CSCL micro-script phase, the activities' scenario is structured, within Neverwinter, as well as the scenarios' dialogues with the NPCs (Non-Playable Characters) and the possible answers that the team may choose. Although the game's PEGI is 16+, the scenarios in which the participants will engage are based on the 12+ principles of unrealistic violence and imaginary enemies, but this scenario cannot be applied to younger children due to the anthropomorphic graphic design of the environment.

Figure 7: Gameplay screenshot

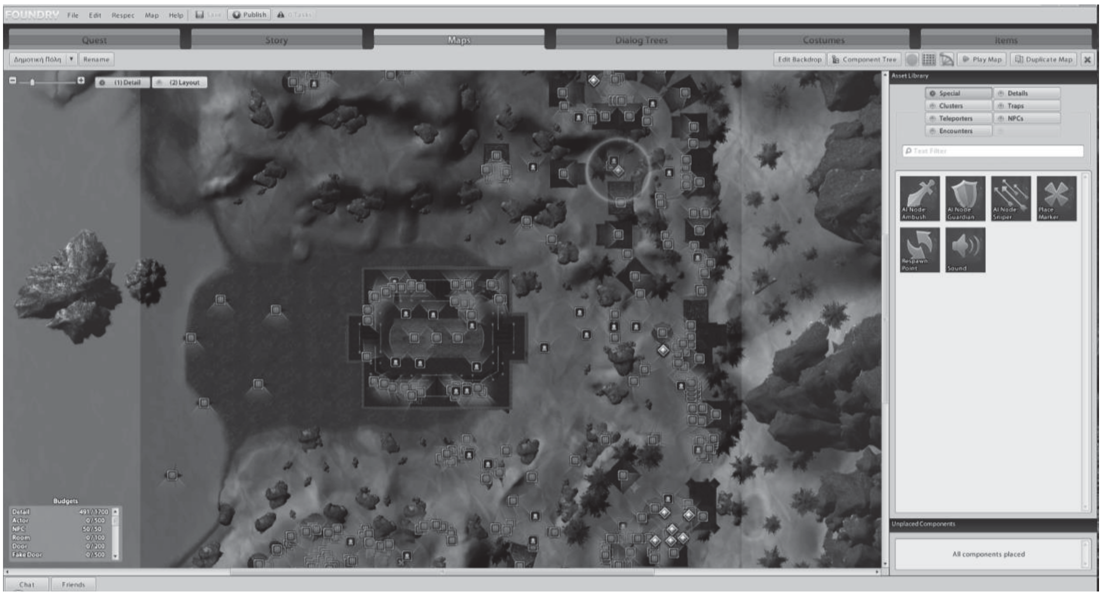

Figure 8: In-game map of the City

Unfortunately, the current game is a non-educational oriented commercial platform, and therefore, no other interaction system is available beyond the multiple choices. However, the PBL structure is kept fully in the conceptual framework. A separate and independent mission was created for each cognitive field, using the same map as a micro world to reality.

3.5 Implementation

Although the research is still in progress, the pilot implementation of the script, to the first team, which was made under the supervision of a tutor, is presented. In the end, every participant was examined with a questionnaire, for their progress to be estimated and compared with their previous score in the conventional teaching. In the following table we present the strongest intelligence estimated by a psychologist qualified in learning difficulties, the class and the role that each participant choose, in order to create a future pattern in role assignment.

Table 4: Team formation for the pilot implementation

Name	Age	Strong Intelligence	Class	Role
Paul	12	Kinesthetic	Trickster Rogue	Leader
Fotis	12	Logical - Mathematical	Guardian Fighter	Scout
George	12	Intrapersonal	Devoted Cleric	Councilor
Angelos	13	Logical - Mathematical	Great Sword Fighter	Councilor

After a short presentation of the problem before every quest, the team started one quest at a time with a 5 minutes break between. The team had 25 minutes for the history quest and 20 minutes for the other topics and they succeeded in finishing in time and completing the mission. During the process, there was a detailed log of the group's dynamics, as well as excerpts of their discussions resulting to the following findings:

- Excitement for the creation and development of a digital character.
- Maintaining the concentration throughout the process.
- Bullying reduction, through the outburst of the impulsive aggression into the game.

Table 5: Results from in-game and written assessment of the acquired knowledge

	Duration			Neverwinter			1st test			2nd test		
Name	Phys	S.S.	Hist.	Phys	S.S.	Hist.	Phys	S.S.	Hist.	Phys	S.S.	Hist.
Paul							12/13	7/7	14/16	13/13	7/7	14/16
Fotis	30	20	40	9/9	6/6	17/17	13/13	7/7	15/16	13/13	7/7	16/16
George							13/13	7/7	14/16	13/13	7/7	15/16
Angelos							13/13	7/7	16/16	11/13	6/7	13/16

During the implementation, it was observed that the participants developed ways to faster mine knowledge from the educational material, and they became more skilled users. The evaluation of the acquired knowledge was made with short questions where the participants had to answer briefly and without help either from the tutor or from the other participants. The questions were given once after the quest competence and once a week after, and the results showed an increased performance to all their previous score even from the school's evaluation of the same cognitive section.

4. In conclusion

In conclusion, with an overall success of the first implementation both in the cognitive and social development of the individual combined with the development of new skills or the improvement of the those already acquired, we have to acknowledge the need for a thorough research on the field of alternative learning and especially the use of MMOPRGs in the educational process, and eventually their transition into integrated educational environments. In order to achive such pedagogical progress we have to, develop an adaptive educational MMORPG suitable for all ages, investigate whether the target group fullfills the conditions in accessibility and expertise, and continue the research to stablize the suggested teaching model based on the psychoanalytic principles and the connection to digital systems.

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Edmodo as a Gamification Platform: Review and Plans

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Abstract: Educational services based on web 2.0 showed clearly that new media in education are not just online courses and quizzes. Faculty of Mass Media Communication, University of Ss. Cyril and Methodius started to experiment with Edmodo within few subjects in academic year 2014/2015. During the year, we found this tool is much handier than we expected. Not only for K12 but in university education as well. Survey at the end of academic year has shown that the best features for students are the clear way to turn in the assignments and clever overview of all results. Gained experience and up to now idled features encourage us to go further. In keeping up with current trends, we decided to utilize Edmodo as a gamification platform. This paper is a review of experiences with utilizing the Edmodo in gamification. It describes basic parts of game mechanics and it compares their accessibility in the Edmodo and few other online services. It is a fact that Edmodo had not been developed as a gamification tool. Up to now, several other commercial services have been developed. On the other hand, user's experiences have indicated the Edmodo is utilizable for this purpose. We solve the range of its applicability and think about available alternatives. Finally, based on the findings we present a plan of gamification featured subjects for the academic year 2015/2016.

Keywords: gamification, social media, Edmodo, examination

1. Introduction

The use of game elements is most frequently connected to the motivation to look into the requested schoolwork. Besides that it also significantly influences the mutual interaction of students and supports cooperation (Ejsing-Duun and Skovbjerg, 2014). It perfectly complements the *learning by doing* concept mentioned also by Petranová (2011). It is obvious that the game elements (see section 2) can be also used effectively when teaching more theoretical stuff. Gamification has the potential of research activities as well – e.g. when defining the type of information young people look for in the online environment (Vrabec, 2010).

Even though it is not a necessity, gamification of education is very closely connected to the platform by use of which it is performed. After 2000 several services were established trying to find new possibilities of new technologies in the educational process. We can include Edmodo among the best established. The purpose of Edmodo and similar services is to integrate the outputs of other sources into one whole and provide it with communication and assessment background. Positive experience with using Edmodo at basic and secondary schools (e.g. Holland and Muilenburg 2011; Fardoun et al. 2012; Wallace 2013) has encouraged us to try it also in the environment of academic education. During the academic year 2014/2015 at the University of Ss. Cyril and Methodius in Trnava we applied it in selected courses as the only communication and assessment platform for marketing communication students. It proved very successful during two terms. Positive reactions of students were a strong impulse when considering the use of next feature – badges. For that reason we examined even more thoroughly the possibility of gamification by Edmodo during the last few weeks. We compared them with the competition and tried to create a concept that would entertain, encourage to further education and that would be able to eliminate some negative phenomena in current education (e.g. huge amount of seminary works handed in after deadline, attendance under the 70 %).

2. Basic parts of game mechanics

Sarah Smith-Robbins mentions three basic features of each game: 1) *a goal, 2) obstacles, 3) collaboration or competition* (Smith-Robbins, 2011). Anderson, in the context of gamification, lists four principles of game design: 1) game features and challenges, 2) conflict and choice, 3) feedback and 4) goals and rewards. (Anderson, 2012). Individual game elements are diverse. The most frequent ones are those mentioned by Anderson as well: points, levels, leaderborards, achievements, quests (Anderson, 2012). However, all mentioned things are only the building elements. If their use does not rely upon the above mentioned principles, it is not gamification.

Kapp distinguishes two types of education gamification. *Content* gamification applies game elements to the educational content itself. For example, adding *story* to a compliance course. Adding these elements makes the content more game-like. On the other hand, applying these changes does not necessarily mean that teaching will turn into a game. According to Kapp this is topic of *structural* gamification. Its objective is the internal motivation of students – the use of game elements to propel students to deal with the required content. It does not deal with changes in the content itself. (Kapp, 2013).

3. Game features in educational platforms

Although there are many discussions about gamification in education, the implementation is not easy at all. Several online services include the elements of game mechanics. However, the possibilities of gamification are rather limited. As far as communication and social platforms are concerned, neither Google Classroom nor Open Class has any game mechanisms. The situation is better at the popular web site Schoology which supports the system by assigning badges. Moreover, its plug-in Gamifikator looks promising. However, it is still just alpha version that is unsuitable for live production. Our survey has shown that nowadays it is Edmodo that can do the most. It is supports very useful function for gamification in addition to badges. It is the possibility to gather students in one group (subject) into smaller groups. If we call these small groups Level 1, Level 2, etc. we can organize students into various levels depending on their results. The third element applicable in gamification through Edmodo is the plug-ins, especially the Classroom Charts. This application allows defining various positive and negative events with different point values. A teacher is flexible in assigning points (for a good question, exceptional activity, etc.) or deducting them (disturbing, coming late, etc.). We must admit that Edmodo is not a perfect solution. It is mainly due to the absence of leaderboards which have a strong motivational character. Speaking about gamification Talent LMS is probably the top for now. This full-blown LMS has been since its beginning developed as a gamification platform. In this way it got ahead of other services. However, it is a commercial application. When considering the stuff accessible for free it is Edmodo which is nowadays probably the best that can be applied in the gamification of education. Table 1 reflect a presence of particular game elements in selected LMS.

Table 1: Comparison of game elements in the examined educational services

	Edmodo	Schoology	Open Class	Google Classroom	Moodle	Talent LMS*
Badges	•	•			•	•
Leaderboards					•	•
Levels	•					•
Points	•	•				•
Achievements						•
Quests						•

4. Ready to play

Based on very good experience with using Edmodo in academic year 2014/15 we have decided to implement the elements of game mechanics into it. For the academic year 2015/16 we have prepared a plan that significantly changes the method of assessment. The change means that instead of several seminary works and final test the students will get points and badges for their activity throughout the whole academic year. We have prepared the gamification plan in a way that allows both learning the schoolwork and *improving the approach to the study.* A brief comparison of characteristics of a good and excellent student was the base for these objectives (Table 2).

Table 2: Good student vs. excellent student

Good student	Excellent student
Attends lectures Hands in seminary works on time Sometimes joins the discussion	Attends lectures on time Hands in seminary works in advance, not in the nick of time Does homework at least to 90 % Studies his area also outside the classroom Tries to use the knowledge in practice Discusses

Based on the analysis we have set the following goals:

- Better students´ attendance
- Achieve more active participation in discussions
- Significantly reduce the number of seminary work submitted on the deadline day

- Motivate to extracurricular education in the field
- Motivate to try out online marketing procedures in real projects

With regard to Edmodo possibilities the core of course gamification will lie in collecting the badges. Their number and difficulty will be reflected in the final assessment. Anyone who makes at least minimal efforts in the study will be able to get easy badges. Medium badges will be more important when talking about the final assessment. To get them will require significantly higher rate of engagement, even beyond the scope of lectures. To get the best assessment possible (A) will be conditioned by getting at least one hard badge. We designed fifteen badges in total; they are described in Table 3. The system of assigning badges is convenient for us as it respects the philosophy of positive assessment. When assessing the activity we wanted to keep the freedom of making errors and experimenting which belong among the key features of games for children (Klopfer et al., 2009). Due to this fact we abandoned subtracting points for late submission of seminary works and rather designed badges for their repeated submission in advance. Getting badges will be reflected also in the criteria for the course completion. The designed scale in Table 4 is the first draft that will be reassessed at the end of the winter term and adjust when necessary.

Table 3: List of badges

Easy badges	Medium badges	Hard badges
80% attendance 80 % seminary works submitted in advance Reading professional literature and writing a review Getting 250 XP in assessing the administration of Facebook page Getting 200 XP for seminary works	Placing in Top 20 in year´s SEO competition Documented participation in professional conference Getting 350 XP in assessing the administration of Facebook page Getting 100 XP for active discussion in lectures Getting 400 XP for seminary works Marketing communication for selected project for at least 1 month	Completing work experience of at least 40 hours Placing in Top 3 in year´s SEO competition Getting 500 XP in assessing the administration of Facebook page Getting arbitrary marketing certificate (Google Analytics, AdWords...)

Table 4: Proposed assessment scale of students

Mark	Required badges
A	4 easy + 3 medium + 1 hard
B	4 easy + 3 medium
C	4 easy + 2 medium
D	4 easy + 1 medium
E	3 easy + 1 medium
F×	Fewer than above-metioned

5. Conclusion and future work

Edmodo is not only an excellent communication and social platform. It seems to be also quite good gamification platform. Considering its possibilities we have designed a gamification plan for the Online marketing course that we have and teach at the Faculty of Mass Media Communication, UCM. We will carry out the educational process in the academic year 2015/2016 according to this plan. We consider gathering the badges as favourable due to a) a freedom of choice, b) a time-independency and c) encouragment to personal growth. In other words, the student himself chooses which criteria he wants to fulfil and the right time to do that. Badges should also motivate to regular attendance at (still optional) lessons. It remains to be decided how to control it effectively. Most probably via special unique link published during the lesson (students will have to open it on their mobiles to verify their presence). This experiment will be used to verify the real applicability of Edmodo in the field of gamification. We are really curious about the reactions of students. Last but not least, the experiment is a perfect opportunity to try this concept of education in the environment of the Slovak higher education.

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