E-iED 2014

PROCEEDINGS

ISSN 2325-5048

ImmersiveEducation.org

EDITORS:

Johanna Pirker, Graz University of Technology

Martin Ebner, Graz University of Technology

Kai Erenli, University of Applied Sciences BFI Vienna

Rainer Malaka, University of Bremen

Aaron Walsh, Immersive Education Initiative

iED

About the Immersive Education Initiative

The Immersive Education Initiative is a non-profit international collaboration of educational institutions, research institutes, museums, consortia and companies. The Initiative was established in 2005 with the mission to define and develop standards, best practices, technology platforms, training and education programs, and communities of support for virtual worlds, virtual reality, augmented and mixed reality, simulations, game-based learning and training systems, and fully immersive environments such as caves and domes.

Thousands of faculty, researchers, staff and administrators are members of the Immersive Education Initiative, who together service millions of academic and corporate learners worldwide.

Chapters support the rapid and continued growth of Immersive Education throughout the world, and constitute the geographically distributed structure of the organization through which regional and local members are supported and enriched. Chapters organize officially sanctioned Summits, Days, workshops, collaborations, seminars, lectures, forums, meetings, public service events and activities, technical groups, technical work items, research, and related activities.

About Immersive Education Summits

Immersive Education (iED) Summits are official Immersive Education Initiative conferences organized for educators, researchers, administrators, business leaders and the general public. iED Summits consist of presentations, panel discussions, break-out sessions, demos and workshops that provide attendees with an in-depth overview of immersion and the technologies that enable immersion. iED Summits feature new and emerging virtual worlds, game-based learning and training systems, simulations, mixed/augmented reality, fully immersive environments, immersive learning and training platforms, cutting-edge research from around the world, and related tools, techniques, technologies, standards and best practices.

Speakers at iED Summits have included faculty, researchers, staff, administrators and professionals from Boston College, Harvard University (Harvard Graduate School of Education; Berkman Center for Internet and Society at Harvard Law School; Harvard Kennedy School of Government; Harvard University Interactive Media Group), Massachusetts Institute of Technology (MIT), MIT Media Lab, The Smithsonian Institution, UNESCO (United Nations Educational, Scientific and Cultural Organization), Federation of American Scientists (FAS), United States Department of Education, National Aeronautics and Space Administration (NASA), NASA Goddard Space Flight Center, IBM, Temple University, Stanford University, Internet 2, Synthespian Hollywood Studios, Cornell University, Loyola Marymount University, Kauffman Foundation, Amherst College, Teacher's College at Columbia University, Boston Library Consortium, Stratasys Ltd., Duke University, Oracle, Sun Microsystems, Turner Broadcasting, Open Wonderland Foundation, Gates Planetarium, Carnegie Mellon University, Vertex Pharmaceuticals, Intel Corporation, University of Maryland College Park, Southeast Kansas Education Service Center, South Park Elementary School, University of Colorado Boulder, Boston Public Schools (BPS), Berklee College of Music, Computerworld, Stanford University School Of Medicine, University of Notre Dame, Bill & Melinda Gates Foundation, Emerson College, Carnegie Museum of Natural History, Imperial College London (UK), University of Zurich (Switzerland), realXtend Foundation

(Finland), The MOFET Institute (Israel), Keio University (Japan), National University of Singapore (NUS), Coventry University (UK), Curtin University (Australia), Giunti Labs (Italy), European Learning Industry Group, Open University (UK), Universidad Carlos III de Madrid (Spain), University of Oulu (Finland), Royal Institute of Technology (Sweden), École Nationale Supérieure des Arts Décoratifs (EnsAD; France), Interdisciplinary Center Herzliya (Israel), Graz University of Technology (Austria), University of Ulster (Ireland), National Board of Education (Finland), Eindhoven University of Technology (Netherlands), University of West of Scotland (UK) , University of St. Andrews (Scotland), University of Essex (UK), Universidad Complutense de Madrid (Spain), Ministry of Gender, Health and Social Policies (Andalucía, Spain), Manchester Business School (UK), City of Oulu (Finland), University of Vienna (Austria), University of Barcelona (Spain), Government of New South Wales (Australia), Eötvös Loránd Tudományegyetem (Hungary), Universidade Federal do Rio Grande do Sul (UFRGS; Brazil), Universidad Politécnica de Madrid (Spain), and many more world-class organizations.

E-iED 2014

The world's leading experts in immersion and immersive technology convened November 24-26 at University of Applied Scienced bfi Vienna (Austria) for the 4th European Immersive Education Summit in conjunction with Graz University of Technology.

Building on the previous 8 years of Immersive Education conferences the 4th European Immersive Education Summit (E-iED 2014) theme is:

"Science meets Business - From Innovative Research to Successful Services and Products"

E-iED 2104 brings together researchers, developers, educators, decision makers, and industry from around the world. EiED 2014 covers a broad spectrum of Immersive Education interests and concerns, ranging from emerging trends and technologies, world-class research and best practices, to the development and marketing of innovative products and services.

E-iED 2014 consists of scientific presentations, poster sessions, panel discussions, and break-out sessions. A newly introduced hands-on demo stream combines a short paper presentation with an extended hands-on presentation for the attendees. Following a bottom-up approach, special tracks and workshops cover emerging topics and trends suggested and organized by the community and focused groups. Also speed sessions enable participants to present an aspect of their work or interest in a fun and speedy way. The summit also offers a platform to explore research collaborations and provides international research consortia with an opportunity share their results.
For the main conference, topics of interest in the context of immersive environments include the following:

Topics of interest addressed through the iED 2013 Call for Proposals (CfP) included:

- Immersive Techniques, Systems and Devices
- Behavioral and Pedagogical Analysis
- Games and Entertainment
- A Glance into the Future: Innovations, Challenges and Applications
- Art and Creativity

Preface from the Editors

Immersive Education has been an ongoing topic for educators, researchers and businesses since years. With the technical evolution Immersive Scenarios are becoming more and more mainstream. What once had to be developed, deployed and maintained by specialists can now be done by a broad audience. Ongoing research scenarios range from architectural applications such as pre-visualization and augmented enhancements to Data Goggles and game-based learning. In order to discuss upcoming topics and research results Immersive Education (iED) Summits were established in 2005. As organizer serves the Immersive Education Initiative, a non-profit international collaboration of educational institutions, research institutes, museums, consortia and companies.

Immersive Education Summits must be seen as official Immersive Education Initiative conferences organized for educators, researchers, administrators, business leaders and the general public. iED Summits consist of a broad variety of presentations, panel discussions, break-out sessions, demos and workshops that provide attendees with an in-depth overview of immersion as well as technologies enabling immersion. iED Summits feature new and emerging virtual worlds, game-based learning and training systems, simulations, mixed/augmented reality, fully immersive environments, immersive learning and training platforms, cutting-edge research from around the world, and related tools, techniques, technologies, standards and best practices.
The 4th European Education Summit organized in conjunction with the University of Applied Sciences bfi Vienna, Graz University of Technology (both Austria) and the University of Bremen (Germany) has a set its focus on “Science meets Business”.
It will bring together high-qualified experts from all over the world. The acceptance rate was 62%, in order to aim for a high quality of work. The Summit will also host a fully immersed location-based-learning game, which aids to engage participants for an Immersive Sightseeing Experience in the Inner City of Vienna.

Martin Ebner, Kai Erenli, Rainer Malaka, Johanna Pirker & Aaron Walsch
Vienna, November 2014

Organisation

We like to express our gratitude to all supporters of the conference as well as chairs, reviewers, contributors, organisers. We are equally indebted to all helping hands before and during the whole event.
Additionally we like to thank the following people:

EiED Summit General Chairs

General Chair	Rainer Malaka University of Bremen, Germany
Local Chair	Kai Erenli University of Applied Science BFI Vienna, Austria
Program Chair	Martin Ebner Graz University of Technology, Austria
Special Sessions Chair	Johanna Pirker Graz University of Technology, Austria
Publicity & Public Relations	Roxane Koitz Graz University of Technology, Austria
Local Arrangements	Angelika Sönnichsen University of Applied Science BFI Vienna, Austria
EiED Summit Advisor	Aaron E. Walsh, Immersive Education Initiative and Boston College, USA

EiED Summit International Chairs

North America Chair	Aaron E. Walsh Immersive Education Initiative and Boston College, USA
North America Chair	David Guralnick Columbia University, USA

South America Chair	Andreas Pester Carinthia University of Applied Sciences, Austria
South America Chair	Paulo Sampio University of Salvador (Unifacs), Brazil
Asia Pacific Chair	Henry Been-Lirn Duh University of Tasmania, Australia
Asia Pacific Chair	Torsten Reiners Curtin University, Australia
Europe	Leonel Caseiro Morgado Universidade Aberta, Portugal
Africa Chair	Mathy Vanbuel Audiovisual Technologies, Informatics & Telecomm., Belgium
Industry Relations Chair	Roman Anlanger University of Applied Science BFI Vienna, Austria

Program Committee and Reviewers

Dietrich Albert	University of Graz, Austria
Colin Allison	University of St. Andrews, UK
Mohammad Al-Smadi	Tallinn University, Estonia
Leena Arhippainen	Center for Internet Excellence, Finland
Juan Carlos Augusto	Middlesex University, UK
Theo Bastiaens	Open University Hagen, Germany
Marcus Birkenkrahe	HWR Berlin, Germany
Pierre Bourdin	University of Barcelona, Spain
Manuel Castro	Universidad Nacional de Educación a Distancia, Spain
J. Cecil	Oklahoma State University, USA
Erik Champion	Curtin University, Australia
Vanessa Chang	Curtin University, Australia
Jennifer DeBoer	Massachusetts Institute of Technology, USA
Sara de Freitas	Curtin University, Australia
Nellie Deutsch	Ort Hermelin College of Engineering, Israel
Jon Dron	Athabasca University, Canada

Henry Been-Lirn Duh	University of Tasmania, Australia
Eric Duval	KU Leuven, Belgium
Martin Ebner	Graz University of Technology, Austria
Justin Ehrlich	Western Illinois University, USA
Jennifer Elliott	University of Cincinnati, USA
Kai Erenli	University of Applied Science BFI Vienna, Austria
Baltasar Fernandez-Manjon	Universidad Carlos III de Madrid, Spain
Bekim Fetaji	South East European University, Macedonia
Christian Phish Glahn	ETH Zurich, Switzerland
Stefan Göbel	TU Darmstadt, Germany
Judson Harward	Harvard University, USA
Stylianos Hatzipanagos	King's College London, UK
Jaanicke Baalsrud Hauge	University of Bremen, Germany
Aurelie Herbet	École Nationale Supériore des Arts Décoratifs, France
Oliver Hödl	TU Wien, Austria
Margit Höfler	Graz University of Technology, Austria
Michael J. Jacobson	University of Sydney, Australia
Bjørn Jæger	Molde University College, Norway
Monique Janneck	Lübeck University of Applied Sciences, Germany
Bruno Joho	Lucerne University of Applied Science and Arts, Switzerland
Ferial Khaddage	Deakin University Australia, Austrialia
Barbara Kieslinger	Centre for Social Innovation, Austria
Ralf Klamma	RWTH Aachen University, Germany
Timo Koskela	University of Oulu, Finland
Narayanan Kulathuramaiyer	Universiti Malaysia Sarawak, Malaysia
Edwige Lelievre	Université de Versailles Saint-Quentin-en-Yvelines, France
Vincent Lepetit	Ecole Polytechnique Fédérale de Lausanne, Switzerland
Stephanie Linek	ZBW Leibniz, Germany
David Lowe	University of Sydney, Australia
Santi Caballé Llobet	UOC, Spain
Alok Mishra	Atilim University, Turkey
Felix Mödritscher	University of Applied Sciences Technikum Wien, Austria
Leonel Morgado	Universidade Aberta, Portugal
Alexander Nussbaumer	Graz University of Technology, Austria
Abelardo Pardo	University of Sydney, Australia
Ignazio Passero	University of Salerno, Italy
Panagiotis Petridis	University of Coventry, UK
Andreas Pester	Carinthia University of Applied Sciences, Austria

Johanna Pirker	Graz University of Technology, Austria
Stefanie Quade	HWR Berlin, Germany
Torsten Reiners	Curtin University, Australia
Paulo Sampaio	Universidade Salvador, Brazil
Demetrios G Sampson	University of Piraeus, Greece
Andreas Schmeil	University of Lugano, Switzerland
Wolfgang Slany	Graz University of Technology, Austria
Marcus Specht	Open University of the Netherlands, Netherlands
Kris Staber	arx anima, Austria
Pilar Sancho Thomas	Universidad Complutense de Madrid, Spain
John Venable	Curtin University of Technology, Australia
Aaron E. Walsh	Immersive Education Initiative and Boston College, USA
Steven Warburton	University of Surrey, UK
Mary Webb	King's College London, UK
Gudrun Wesiak	Graz University of Technology, Austria
Lincoln Wood	Curtin University, Australia
Hsuan-Yi Wu	National Taiwan University, Taiwan
Nicole Yankelovich	Open Wonderland Foundation, USA

Workshop on Gamification, Serious Games & Edutainment (GSG-EDU14)

GSG-EDU14 Organisers

Kai Erenli	University of Applied Sciences bfi Vienna, Austria
Stefan Göbel	KOM - Multimedia Communications Lab, TU Darmstadt, Germany
Patrick Hofman	bongfish GmbH, Austria

GSG-EDU14 Program Committee

Marcus Birkenrahe	HWR Berlin, Berlin, Germany
Gerry Creechan	University of West Scotland, Glasgow, Scotland
Leif Oppermann	Fraunhofer FIT, Germany
Johanna Pirker	Graz University of Technology, Austria
Christopher Staber	arx anima, Wien, Austria

Workshop on Immersive Virtual Learning Environments and Advanced (Mobile) Technologies in Education (K-12) (IVLEATE14)

IVLEATE14 Organisers

Martin Ebner	Graz University of Technology, Austria
Pasi Mattila	University of Oulu, Finland

IVLEATE14 Program Committee

Wolfgang Greller	University of Teacher Education Vienna, Austria
Margarete Grimus	University of Technology, Graz, Austria
Klaus Himpsl-Gutermann	University of Teacher Education, Vienna, Austria
Jari Laru	University of Oulu, Finland
Kerstin Mayerberger	University of Augsburg, Germany
Peter Micheuz	Alpen Adria University Klagenfurt; Austria
Michele Notari	University of Teacher Education, Bern, Switzerland
Jonathan Rowe	NC State, North Caroline, USA
Klaus Rummler	University of Teacher Education, Zuerich, Switzerland
Mandy Schiefner	Kaiserslautern University of Technology, Germany
Martin Schön	BIMS e.V, Germany
Sandra Schön	Salzburg Research, Salzburg, Austria
Patrick Schweighofer	University of Applied Sciences, Campus 02, Graz, Austria)
Selver Softic	University of Technology, Graz, Austria
Thomas Strasser	University of Teacher Education, Vienna, Austria
Behnam Taraghi	University of Technology, Graz, Austria
Martin Teufel	University of Teacher Education, Graz, Austria
Stephan Waba	University of Teacher Education Burgenland, Austria
Josef Wachtler	University of Technology, Graz, Austria
Colin Wood	Sydney Area, Australia

TABLE OF CONTENTS

PAPERS: Research, Technical and Theoretical Papers

PRESENTATIONS

POSTERS

Workshop on Gamification, Serious Games & Edutainment

Workshop on Immersive Virtual Learning Environments and Advanced (Mobile) Technologies in Education (K-12) (IVLEATE14)

Paper

Gender Differences in Self-Efficacy Relating to Collaborative Learning in a 3D Virtual World

Authors: Jim Scullion[1]*, Mark Stansfield†[1], Gavin Baxter[1]‡.

Affiliations:

[1]School of Engineering and Computing, University of the West of Scotland.

*jim.scullion@uws.ac.uk

†mark.stansfield@uws.ac.uk

‡gavin.baxter@uws.ac.uk

Abstract:

This paper reports the findings of an empirical study involving 257 participants into the effects on self-efficacy resulting from the use of a 3D virtual world for communication and collaboration. Participants used the virtual world as part of team-based formal learning in tertiary education. The results suggest that use of the virtual world had a significant effect in enhancing self-efficacy in a range of collaborative tasks, and that in relation to gender there was no significant difference between male and female participants.

One Sentence Summary: This study suggests that use of a 3D virtual world enhances self-efficacy in collaborative tasks, with no significant differences between genders.

Introduction

The UNITE project aims to implement and evaluate the use of a 3D virtual world in order to investigate its potential for enhancing communication and collaboration among tertiary education students undertaking team-based project work. The first phase of the project was a large-scale survey of university students [1], which suggested that participants in virtual world activities use online collaboration and communication as part of an informal learning process to increase mastery. This was followed by a pilot implementation of the UNITE virtual world [2]. Based on the successful conclusion of the pilot implementation, the final large-scale empirical phase was undertaken.

The research study explored in this paper aims to investigate whether a 3D virtual world known as UNITE has the potential to enhance students' self-efficacy in terms of students using the platform to share project information and communicate in the virtual world to achieve their project aims.

Scope

Self-efficacy and learning in virtual worlds

The term "virtual world" is used by authors to mean different things. There is no broadly agreed definition of the term [3]. For example, the terms Massively Multiplayer Online Role-Playing Game (MMORPG), Collaborative Virtual Environment, virtual space, Multi-User Virtual Environment, metaverse and others have been used to describe virtual worlds. There are opposing views in the literature regarding a supposed ontological distinction between "games" and "virtual worlds". One paper [4, p185] describes Second Life explicitly as an MMORPG, while another [5, p88] states that "Second Life is not a game". This study uses the Bainbridge [6, p472] definition of virtual world, *viz*. "an electronic environment that visually mimics complex physical spaces, where people can interact with each other and with virtual objects, and where people are represented by animated characters." Specifically, this study relates only to three-dimensional (3D) virtual worlds.

Self-efficacy, a theory predominately associated with the discipline of psychology, relates to an individual's confidence in being able to organise and initiate positive change within them to assist in performing a particular course of action [7, p337]. When placed in an educational context, self-efficacy is often associated with students' belief and motivation in their own ability to undertake a course work assignment that is designed to achieve a personal desirable outcome. Closely aligned to the concept of self-efficacy are the issues of motivation, self-esteem and engagement [8, p159].

The relationship between enhancing self-efficacy through the use of virtual environments is an area receiving attention in the academic literature. For example, a study performed by Zheng et al., [9] explored whether the use of a 3D game-like virtual world called Quest Atlantis would be effective in increasing through a set of tasks within the game, the self-efficacy of Chinese students learning English as a foreign language. One of the main findings of the study was that through the use of the game, the students were able to build their confidence in their reading and writing skills. In comparison, a study undertaken by Henderson et al., [10] found that the use of an immersive virtual world assisted to improve students' self-efficacy beliefs in learning Mandarin in various real-life scenarios. A study conducted by Pellas [8] indicated that through the use of a virtual world in Second Life, students' cognitive and emotional engagement was positively increased when undertaking online courses through this type of technology. Nelson and Ketelhut [11] investigated the relationship between student self-efficacy and guidance use in a Multi-User Virtual Environment (MUVE) science curriculum project. One of the primary findings from the study was that the MUVE assisted students in doing well with their scientific scores though contrary to this there was an apparent lack of use of the embedded guidance system on the platform by students, more so by the low self-efficacy students.

Gender differences in self-efficacy

The relationship between computer self-efficacy and gender has been explored in the literature, but conflicting conclusions have emerged. Broos [12], investigating the relationship between ICT self-efficacy form a gender perspective, reports a positive connection between frequent use of ICT and self-efficacy for males and no corresponding connection for females. In contrast to this Tømte and Hatlevik [13] reported positive relationships for both males and females between

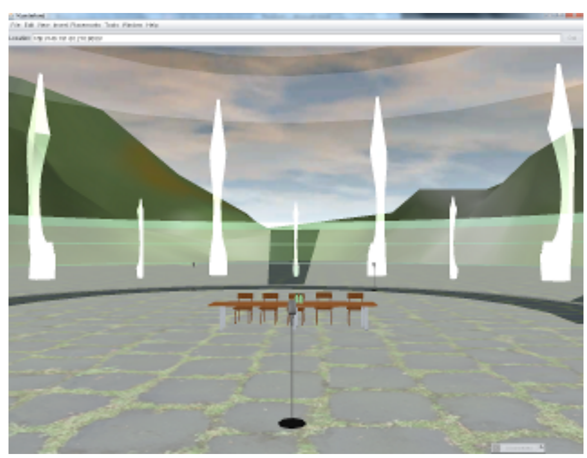
ICT self-efficacy and ICT usage. Cassidy and Eachus [14], in an investigation of computer self-efficacy for 94 males and 113 females, found that males had higher computer self-efficacy than females. Chou [15] reported that computer self-efficacy results were higher for males than females. Peng et al. [16] report mixed results for gender differences in computer self-efficacy. They report that no gender differences were evident in self-efficacy ratings for use of the Internet, but that significantly higher self-efficacy beliefs were found for males in respect of their ability to use the Internet for communication. In a meta-analysis of 187 studies Huang [17] concludes that females display higher academic self-efficacy than males in language learning, while males exhibit higher academic self-efficacy in mathematics, computer, and social sciences learning. He identified a need for further research in this area.

UNITE - A Large-Scale Empirical Study

The UNITE virtual world and research design are described in detail in Scullion et al. [18]. A brief description is also given below. The final empirical phase of the UNITE project involved: participants from Scotland, England and the Republic of Ireland; both further education and higher education establishments; educational levels ranging from pre-university to postgraduate; and participants from the Computing and Health cognate areas. Data collection for this final phase was recently completed and results from the first tranche [19] indicate some significant improvements between students' pre-test and post-test self-efficacy ratings for a range of tasks associated with team-based project work.

UNITE was created using Open Wonderland (http://openwonderland.org), a Java-based open source toolkit for creating 3D virtual worlds [20]. Participants were initially directed to a "Starting" location in-world. They could then navigate, using either menu selection or navigation portals, among eight locations that were pre-populated with 3D and other content with the intention of providing a visually interesting environment. Participants could add their own 3D or 2D content by dragging and dropping the files in-world. Screenshots of two of these in-world locations are illustrated in Figure 1 below.

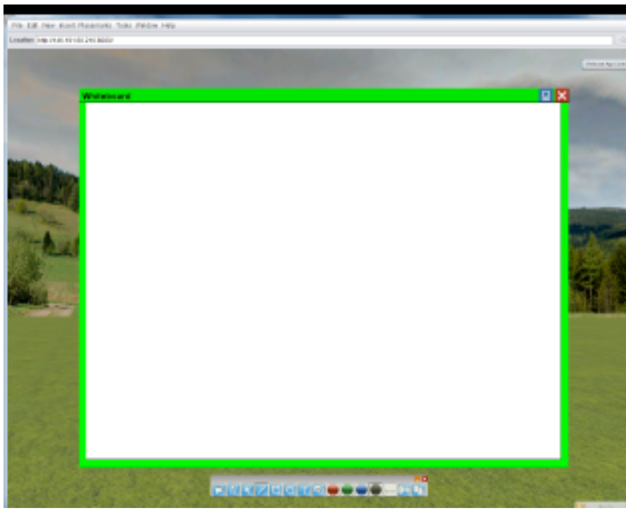
"Meeting Complex" Location



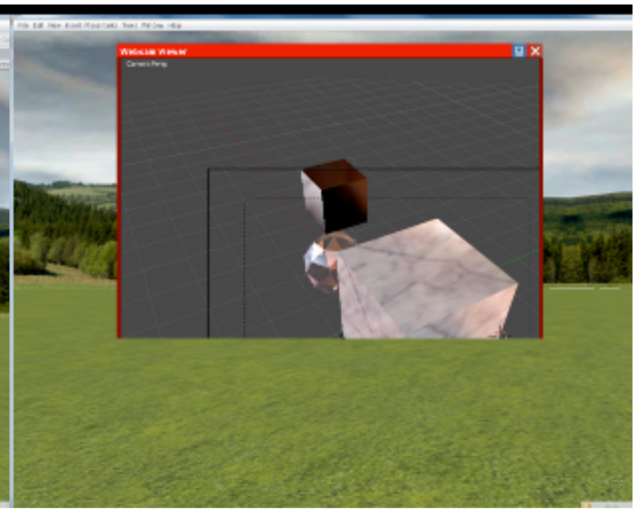
"Auditorium" Location

Figure 1: Examples of In-World Locations

Participants were provided with a range of in-world tools and facilities for communication and collaboration: synchronous text chat, voice chat, interactive whiteboard, sticky notes, audio and video playback and recording, screen sharing, drag and drop display of image and PDF files, and the conversion of any MS Office Open Office or Libre Office file to PDF format for display in-world. Examples are shown in figure 2 below.

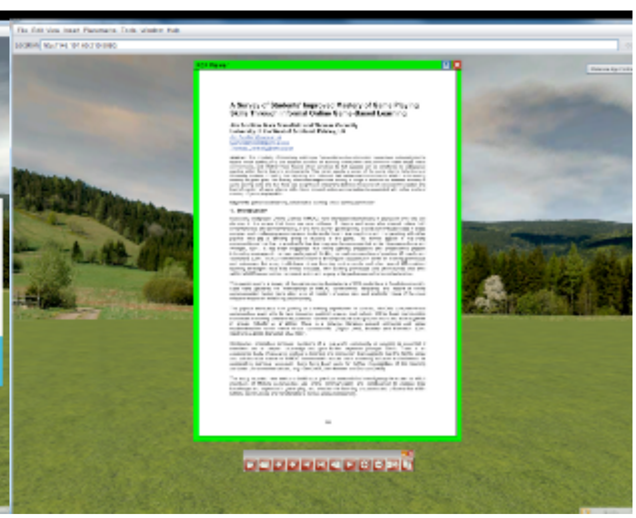


Interactive Whiteboard



Screen Sharing (Showing Blender 3D Modelling)

Presentation Slides



PDF Viewer

Figure 2: Examples of In-World Tools and Facilities

Research Methods

A quasi-experimental research design using pre-test and post-test surveys was adopted. Online questionnaires were designed and administered using Survey Monkey https://www.surveymonkey.com. The design of the questionnaires was based on the principles described by Bandura [21].

Participants

The final empirical phase involved 257 participants in 8 cohorts. These are described in table 1 in the Supplementary Materials. In accordance with the ethics protocol agreed with the partner institutions they have been anonymised. Participants were given access to UNITE for a period of 10 weeks. They were provided with video tutorials on how to log in and use the in-world facilities. Their method of use of the facilities was not prescribed: they were allowed to select the facilities and processes that best suited how they wished to work. The facilities were used by participants to support team activities in a variety of ways, including: brainstorming to select a suitable project, then to identify content and processes required to complete it. This enabled participants to develop their own processes in reaching a desired solution. In addition, UNITE allowed participants to conduct on-line team meetings to discuss project planning and management and other task-related issues. The collaborative creation of text documents and other content and rehearsal of a presentation that was to be delivered face-to-face as part of their coursework, enabled participants to experience and appreciate other perspectives.

Pre-test survey questions

Participants were asked to provide their unique matriculation number, then the following demographic data: institution; gender; age and full-time or part-time study.

Prior experience of virtual worlds - Respondents were asked to indicate if they had prior experience of Massively Multiplayer Online Games (MMOG) or of social virtual worlds like Second Life. If they responded that they had, they were asked to indicate how many hours per week, on average, they spend in either activity using the following time bands: 0-1; 1-5; 6-10; 11-15; 16-25 and more than 25.

Can a 3D virtual world help student collaboration? – Respondents were asked to indicate on the following scale the extent to which they agree that having access to a 3D virtual world could help them to collaborate with other students working on a team-based University project: Strongly Disagree; Disagree; Agree; Strongly Agree and Don't Know/No Opinion. They were also given the opportunity to add an optional freeform comment at this point.

Perceived Self-Efficacy – Respondents were asked to rate how certain they were that they could successfully carry out a range of activities by recording a number from 0 to 100 where: 0=Cannot do at all; 50=Moderately can do and 100=Highly certain can do. The activities listed were: Use a computer; Use an online virtual world or MMOG; Work well in a group; Contribute to discussion in a group; Take an active part in group problem solving; Participate in planning group activities; Contribute ideas for consideration by the group; Comment on ideas from other group me members and Make a presentation to a group.

Post-test survey questions

Participants were asked to provide their unique matriculation number, which allowed matching with the corresponding pre-test responses for that participant.

Use of the UNITE virtual world - Respondents were asked to indicate if they had made use of the 3D virtual world provided as part of this research.

Did the UNITE 3D virtual world help collaboration? – Respondents who answered that they had used the UNITE virtual world were asked to indicate on the following scale the extent to which they agreed that having access to the UNITE 3D virtual world had helped them to collaborate with other students working on their team-based University/College project: Strongly Disagree; Disagree; Agree; Strongly Agree and Don't Know/No Opinion. They were also given the opportunity to add an optional freeform comment at this point.

Perceived Self-Efficacy – Respondents were asked to rate how certain they were that they could successfully carry out a range of activities by recording a number from 0 to 100 where: 0=Cannot do at all; 50=Moderately can do and 100=Highly certain can do. The activities listed were: Use a computer; Use an online virtual world or MMOG; Work well in a group; Contribute to discussion in a group; Take an active part in group problem solving; Participate in planning group activities; Contribute ideas for consideration by the group; Comment on ideas from other group members and Make a presentation to a group.

Results

Pre-test results for self-efficacy

The tasks for which respondents indicated they had the highest perceived self-efficacy were "Use a computer" (Mean =85.37 SD=18.634) and "Comment on ideas from other group members" (Mean=72.81 SD=20.629). The tasks for which respondents indicated they had the lowest perceived self-efficacy were "Make a presentation to a group" (Mean =56.64 SD=26.211) and "Use an online virtual world or MMOG" (Mean=66.82 SD=35.243). A detailed breakdown of these responses is shown in table 2 in the Supplementary Materials.

A Mann-Whitney test indicated that there were no statistically significant ($p<.05$) differences in pre-test scores between participants who used UNITE and participants who did not use UNITE for any of the activities used for assessing self-efficacy. The results are shown in table 3 in the Supplementary Materials.

Post-test results

Following data cleaning and matching 161 complete matched pre-test and post-test responses had been received. A breakdown of these by cohort is shown in table 4 in the Supplementary Materials.

Of these 161 respondents, 85.09% (n=137) used UNITE and 14.91% (n=24) did not. 70.8% (n=114) were male and 29.2% (n=47) were female. The mean age of respondents was 23.03

(SD=5.76), with a range between 17 and 53. 96.9% (n=156) were full-time students and 3.1% (n=5) were part-time students.

Differences between pre-test and post-test scores for self-efficacy for all respondents were examined using a Wilcoxon matched-pairs signed ranks test. The results for all participants are shown in table 5 in the Supplementary Materials.

For the respondents who did not use UNITE, there were no statistically significant ($p<.05$) differences between pre-test and post-test scores for any of the activities used for assessing self-efficacy. For the respondents who did use the UNITE virtual world there were statistically significant differences ($p<.05$) between pre-test and post-test scores for all of the activities used for assessing self-efficacy, with post-test scores higher than pre-test scores.

Considering only male participants (n=114), 85.09% (n=97) used UNITE and 14.91% (n=17) did not. The results for male participants are shown in table 6 in the Supplementary Materials.

For male respondents who did not use UNITE, there were no statistically significant ($p<.05$) differences between pre-test and post-test scores for any of the activities used for assessing self-efficacy. For male respondents who did use the UNITE virtual world there were statistically significant differences ($p<.05$) between pre-test and post-test scores for all of the activities used for assessing self-efficacy, with post-test scores higher than pre-test scores.

Considering only female participants (n=47), 85.11% (n=40) used UNITE and 14.89% (n=7) did not. The results for female participants are shown in table 7 in the Supplementary Materials.

For female respondents who did not use UNITE, there were no statistically significant ($p<.05$) differences between pre-test and post-test scores for any of the activities used for assessing self-efficacy. For female respondents who did use the UNITE virtual world there were statistically significant differences ($p<.05$) between pre-test and post-test scores for all of the activities used for assessing self-efficacy, with post-test scores higher than pre-test scores.

Interpretations

This paper reports the findings of an empirical study involving 257 participants into the effects on self-efficacy resulting from the use of the UNITE 3D virtual world for communication and collaboration during team-based formal learning in tertiary education.. The results suggest that use of the UNITE virtual world had a significant effect in enhancing self-efficacy in a range of collaborative tasks, and that in relation to gender there was no significant difference between male and female participants, either in the choice of whether or not to use UNITE or in self-efficacy enhancement. These results support the findings of Tømte and Hatlevik [13].

It is recognised that the multiple testing that was used may lead to a potential increase in Type I errors that can occur when statistical tests are used repeatedly. One technique which has been used in an attempt to offset this potential limitation is the Bonferroni correction [22]. However, it is possible that this technique can be conservative, raising the rate of false negatives and failing to identify an unnecessarily high percentage of significant differences in data. It has been suggested that this technique causes more problems than it solves, and that simply describing what tests of significance have been performed is generally the best way of dealing with multiple comparisons [23].

Conclusions

In considering possible reasons for enhanced self-efficacy among users of UNITE it may be informative to consider the responses given by some respondents to the open-ended questions in the post-test survey. Predominantly, these indicated that UNITE was positive in allowing participants to meet in-world and to work on collaborative projects without the need to travel or pre-book a venue or equipment:

"…very beneficial for students especially for times they are not at college as it can give them an opportunity to work together with their classmates in a secure and moderated environment."

"...the use of a 3D virtual world aided collaboration without the need for us to meet in person easily. For example, I was able to create plans for layout for our project by adding images to the world and placing markers on top for others to see."

"Great for students who live a distance away."

"It lets you have a discussion without having to travel. Good for students who don't live close."

"Good for group meetings and practicing our presentation."

As suggested by Huang [17] further longitudinal studies in this area would be a positive contribution to knowledge.

References and Notes:

1. J. Scullion, M. Stansfield, and T. Connolly, A Survey of Students' Improved Mastery of Game Playing Skills Through Informal Online Game-Based Learning, in *Proceedings of the 5th European Conference on Games Based Learning*, Athens (2011), 535–542.
2. J. Scullion, D. Livingstone and M. Stansfield, 2014. Collaboration Through Simulation: Pilot Implementation of an Online 3D Environment. *Simulation & Gaming*. In Press.
3. M. Bell, Toward a Definition of "Virtual Worlds". *Journal of Virtual Worlds Research*, 1(2008).
4. A. Herman, R. J. Coombe & L. Kaye, YOUR SECOND LIFE? *Cultural Studies*, 20 (2006), 184–210.
5. E. Grassian and R. B. Trueman, Stumbling, bumbling, teleporting and flying … librarian avatars in Second Life, *Reference Services Review*, 35 (2007), 84–89.
6. W. S. Bainbridge, The Scientific Research Potential of Virtual Worlds. *Science*, 317 (2007), 472- 476.
7. M.E. Morris, J. Lundell, T. Dishongh and B. Needham, 2009. Fostering Social Engagement and Self-Efficacy in Later Life: Studies with Ubiquitous Computing. In: P. Markopoulos et al. (eds.), *Awareness Systems*, Human-Computer Interaction Series, 335-349.
8. N. Pellas, 2014. The influence of computer self-efficacy, metacognitive self-regulation and self-esteem on student engagement in online learning programs: Evidence from the virtual world of Second Life. *Computers in Human Behavior* 35, 157-170.
9. D. Zheng, M.F. Young, R.A. Brewer, and M. Wagner, 2009, Attitude and Self-Efficacy Change: English Language Learning in Virtual Worlds. *CALICO Journal* 27(1) 205-231.

10. M. Henderson, H. Huang, S. Grant and L. Henderson, 2009, Language acquisition in Second Life: Improving self-efficacy beliefs, *Proceedings ascilite Auckland 2009*, 464-474.

11. B.C. Nelson and D.J. Ketelhut, 2008, Exploring embedded guidance and self-efficacy in educational multi-user virtual environments. *Computer-Supported Collaborative Learning* 3, 413–427.

12. A. Broos, 2005. Gender and information and communication technologies (ICT) anxiety: Male self-assurance and female hesitation. *CyberPsychology & Behavior* 8, 21–31.

13. C. Tømte and O.E. Hatlevik, 2011. Gender-differences in Self-efficacy ICT related to various ICT-user profiles in Finland and Norway. How do self-efficacy, gender and ICT-user profiles relate to findings from PISA 2006. *Computers & Education* 57, 1416 – 1424.

14. S. Cassidy and P. Eachus, 2002. Developing the computer user self-efficacy (CUSE) scale: Investigating the relationship between computer self-efficacy, gender and experience with computers. *Journal of Educational Computing Research* 26, 133–153.

15. H.W. Chou, 2001. Effects of training method and computer anxiety on learning performance and self-efficacy. *Computers in human behavior* 17, 51–69.

16. H. Peng, C.-C. Tsai and Y.-T Wu, 2006. University students' self-efficacy and their attitudes toward the Internet: the role of students' perceptions of the Internet. *Educational Studies* 32, 73–86.

17. C. Huang, 2013. Gender differences in academic self-efficacy: a meta-analysis. *European Journal of Psychology of Education* 28, 1–35.

18. J. Scullion, T. Hainey, M. Stansfield, and T. Connolly, A Pilot Implementation of an Immersive Online 3D Environment for Collaboration Among Computing Students in a Scottish University, in *Proceedings of the 6th European Conference on Games Based Learning,* Cork (2012), 451–459.

19. J. Scullion, M. Stansfield, D. Livingstone and T. Hainey, T., 2013. UNITE: Collaborative Learning in a 3D Virtual World, in: *Proceedings of the 3rd European Immersive Education Summit,* 5–16.

20. J. Kaplan and N. Yankelovich, 2011. Open Wonderland: An Extensible Virtual World Architecture. *IEEE Internet Computing,* 15(5), pp.38–45.

21. A. Bandura, Guide for constructing self-efficacy scales. 2006. *Self-efficacy beliefs of adolescents* 5, 307–337

22. O.J. Dunn, 1961. Multiple Comparisons Among Means. *Journal of the American Statistical Association* 56, 52.

23. T.V. Perneger, 1998. What's wrong with Bonferroni adjustments? *British Medical Journal* 316, 1236–1238.

Supplementary Materials

Table 1. Breakdown of participants by cohort

Table 2. Breakdown of pre-test self-efficacy ratings

Table 3. Mann-Whitney test of pre-test scores between participants who did and did not use

Table 4. Matched pre-test and post-test responses by cohort

Table 5. Effect of UNITE virtual world use on self-efficacy – Wilcoxon matched-pairs signed ranks test (all participants)

Table 6. Effect of UNITE virtual world use on self-efficacy – Wilcoxon matched-pairs signed ranks test (male participants)

Table 7. Effect of UNITE virtual world use on self-efficacy – Wilcoxon matched-pairs signed ranks test (female participants)

Cohort	Institution	Description	Location	Cognate Area	Level Description	Number
1	University One	Post-1992 University	Scotland	Computing	Second year of a four year undergraduate honours degree	80
2	University One	Post-1992 University	Scotland	Computing	Fourth year of a four year undergraduate honours degree	29
3	College One	Further Education College	Scotland	Health	Access to Nursing (pre-degree)	17
4	College Two	Further Education College	Scotland	Computing	Higher National Certificate	48
5	College Two	Further Education College	Scotland	Computing	Higher National Diploma	41
6	College Three	Further Education College	Scotland	Computing	Higher National Certificate	18
7	University Two	Post-1992 University	England	Computing	Postgraduate master's degree	6
8	University Three	Post-1992 University	Republic of Ireland	Health	Postgraduate master's degree	18

Cohort	Institution	Description	Location	Cognate Area	Level Description	Number
					Total	257

Table 1. Breakdown of participants by cohort

Task	Minimum	Maximum	Mean	Std. Deviation
Use a computer	20	100	85.37	18.634
Use an online virtual world or MMOG	0	100	66.82	35.243
Work well in a group	20	100	72.46	19.698
Contribute to discussion in a group	16	100	70.94	20.856
Take an active part in group problem solving	20	100	71.26	22.276
Participate in planning group activities	15	100	68.32	22.185
Contribute ideas for consideration by the group	10	100	70.88	22.881
Comment on ideas from other group members	25	100	72.81	20.629
Make a presentation to a group	2	100	56.64	26.211

Table 2. Breakdown of pre-test self-efficacy ratings

Task	U	z
Use a computer	1320.500	-1.593
Use an online virtual world or MMOG	1535.500	-.520
Work well in a group	1381.500	-1.250
Contribute to discussion in a group	1343.500	-1.431
Take an active part in group problem solving	1511.000	-.634
Participate in planning group activities	1163.500	-2.286
Contribute ideas for consideration by the group	1325.500	-1.518
Comment on ideas from other group members	1280.000	-1.735
Make a presentation to a group	1268.000	-1.790

Table 3. Mann-Whitney test of pre-test scores between participants who did and did not use UNITE

Cohort	Frequency	Percent
1	61	37.9
2	9	5.6
3	15	9.3
4	25	15.5
5	20	12.4
6	11	6.8
7	6	3.7
8	14	8.7
Total	161	100.0

Table 4. Matched pre-test and post-test responses by cohort

	Z	Asymp. Sig. (2-tailed)
(a) Used UNITE virtual world		
Use a computer	-6.381	.000
Use an online virtual world or MMOG	-7.334	.000
Work well in a group	-7.255	.000
Contribute to discussion in a group	-7.503	.000
Take an active part in group problem solving	-5.845	.000
Participate in planning group activities	-7.162	.000
Contribute ideas for consideration by the group	-6.809	.000
Comment on ideas from other group members	-6.696	.000
Make a presentation to a group	-7.277	.000
(b) Did not use UNITE virtual world		
Use a computer	-1.009	.313
Use an online virtual world or MMOG	-.698	.485
Work well in a group	-1.508	.131
Contribute to discussion in a group	-1.470	.142
Take an active part in group problem solving	-1.341	.180
Participate in planning group activities	-.243	.808
Contribute ideas for consideration by the group	-1.635	.102
Comment on ideas from other group members	-1.475	.140
Make a presentation to a group	-1.646	.100

Table 5. Effect of UNITE virtual world use on self-efficacy – Wilcoxon matched-pairs signed ranks test (all participants)

	Z	Asymp. Sig. (2-tailed)
(a) Used UNITE virtual world		
Use a computer	-4.340	.000
Use an online virtual world or MMOG	-4.810	.000
Work well in a group	-5.856	.000
Contribute to discussion in a group	-6.140	.000
Take an active part in group problem solving	-4.428	.000
Participate in planning group activities	-6.103	.000
Contribute ideas for consideration by the group	-5.624	.000
Comment on ideas from other group members	-5.244	.000
Make a presentation to a group	-6.073	.000
(b) Did not use UNITE virtual world		
Use a computer	-1.027	.304
Use an online virtual world or MMOG	-.350	.726
Work well in a group	-1.497	.134
Contribute to discussion in a group	-1.433	.152
Take an active part in group problem solving	-1.139	.255
Participate in planning group activities	-.311	.756
Contribute ideas for consideration by the group	-1.071	.284
Comment on ideas from other group members	-1.645	.100
Make a presentation to a group	-1.269	.205

Table 6. Effect of UNITE virtual world use on self-efficacy – Wilcoxon matched-pairs signed ranks test (male participants)

	Z	Asymp. Sig. (2-tailed)
(a) Used UNITE virtual world		
Use a computer	-4.696	.000
Use an online virtual world or MMOG	-5.336	.000
Work well in a group	-4.256	.000
Contribute to discussion in a group	-4.351	.000
Take an active part in group problem solving	-3.920	.000
Participate in planning group activities	-3.808	.000
Contribute ideas for consideration by the group	-3.849	.000
Comment on ideas from other group members	-4.202	.000
Make a presentation to a group	-4.138	.000
(b) Did not use UNITE virtual world		
Use a computer	.000	1.000
Use an online virtual world or MMOG	-.813	.416
Work well in a group	-.742	.458
Contribute to discussion in a group	-.184	.854
Take an active part in group problem solving	-.948	.343
Participate in planning group activities	.000	1.000
Contribute ideas for consideration by the group	-1.483	.138
Comment on ideas from other group members	.000	1.000
Make a presentation to a group	-1.289	.197

Table 7. Effect of UNITE virtual world use on self-efficacy – Wilcoxon matched-pairs signed ranks test (female participants)

Category: Paper

Title: Utilizing Head Mounted Displays as a Learning Tool for Children with Autism

Authors: Justin Ehrlich[*1] and James Munger[2]

Affiliations:

[1]Western Illinois University, Macomb IL.

[2]Lake Land College, Peoria, IL.

*Correspondence to: JA-Ehrlich@wiu.edu

Abstract: Some of the most promising treatments of Autism spectrum disorder (ASD) involve virtual reality, with its high level of immersion, to simulate and teach social skills in virtual environments. One of the most immersive technologies available, the head-mounted display (HMD), was recently advanced and it is poised as a perfect platform for next generation interventions. Unfortunately the research is nonexistent when it comes to studying this next generation of HMDs, therefore the purpose of this research is to answer two questions: to what extent do those with ASD accept and follow instructions using the HMD and to what extent do these individuals feel presence, induced by the device, while using the HMD when compared to neurotypicals. To answer these questions a between-group study was conducted between those with ASD and those that are neurotypicals. This works finds that while not all of those on the ASD spectrum follow instructions as well as neurotypicals while following instructions using the new HMD, some on the spectrum do. Unfortunately not enough subjects were able to answer the presence questionnaire to determine the difference of presence felt between those with ASD and neurotypicals.

Summary: A study evaluating the next generation of head-mounted displays to treat those with Autism.

1 INTRODUCTION

It is now estimated that 1 in 50 children are afflicted with Autism spectrum disorder (ASD), so it is more important than ever to find effective treatments. Fortunately great strides have been made in finding effective interventions to treat those with ASD, with some of the most promising treatments involve Virtual Reality (VR), with its high level of immersion, to simulate and teach social skills in Virtual Environments (VE) [1–8]. It has also been shown that the more immersive a technology is, the more presence will be felt by the users, allowing the experience to feel like being there [9, 10], so it is important to create interventions with as much immersive technology as possible, and indeed previous work [6, 11] has shown a positive correlation between generalization and presence. One of the most immersive technologies available, the head-mounted display (HMD), has recently received mass attention due to the development of the latest generation, including the Oculus Rift [12]. In the past HMDs had poor viewing angles, high latency, caused eyestrain and headaches, and were cumbersome, which caused the HMDs to be rejected by the community to treat those with developmental disabilities. The new HMDs fix all of these problems and seem to be poised as a perfect platform for next generation interventions, but first researchers must determine if individuals with ASD will accept the use of the new HMD, as problems with the old HMDs caused rejection by those with ASD.

Therefore the purpose of this research is to answer two questions: to what extent do those with ASD or those with general developmental disabilities accept and follow instructions using the HMD and to what extent do these individuals feel presence, induced by the device, while using the HMD when compared to neurotypicals. To answer these questions, a between-group study was conducted between those with ASD and those that are neurotypicals. The ages of the subjects ranged between 6-11 and were selected from a local school. A virtual environment was developed in which subjects were required to perform simple tasks such as recognizing various objects and maneuvering through an environment. Scores were recorded based on the ability to complete the tasks within the virtual environment successfully as well as their acceptance of the HMD itself.

2 Background

Autism is defined as a mental condition, present from early childhood, characterized by difficulty in communicating and forming relationships with other people and in using language and abstract concepts. The dominant treatment for individuals with ASD is based on Applied Behavior Analysis (ABA) [13], introduced by Dr. Ivar Lovaas based on the work by B. F. Skinner in his book The Behavior of Organisms [14]. Scientists regard ABA as the most effective treatment for children with ASD [15]. ABA focuses on the motivation for behavior and uses positive reinforcement to influence desired behavior. ABA attempts to generalize this desired behavior learned in therapy session to the outside world. This generalization is difficult for the individuals because they lack the ability to imagine [16].

Social Skills Training is another approach that encompasses a number of techniques and settings. The individual with ASD are taught by using role-playing, discussions, games, and other activities that may instill social rules [13, 15]. A popular method is “Social Stories,” developed by Carol Gray [17]. Social Stories are scenes presented in any number of ways such as photographs, videos, flash cards, or comics. The scenes portray difficult social situations that individuals with ASD lack the necessary skills to face. Usually a therapist describes the scenes to the individual with ASD and attempts to teach a skill set across the situations that should allow the individual to successfully face the situations when experienced in life. The goal is to encourage the individual to generalize the scene and the learned social skill to the real world.

The computer is an excellent communication tool for individuals with ASD because many of the social limitations that these individuals experience in life are reduced through the safety and anonymity the computer offers while communicating on the Internet. Many individuals with lower functioning ASD learn to use the keyboard before they learn to talk; some even learn to use the keyboard without ever learning to talk. It seems that individuals with ASD, while lacking an effective theory of mind, contain an elevated “theory of physics,” which allows for a much greater use of technology leading to a greater appreciation of computers [15].

In addition to catering to an existing interest in technology, a computer-based virtual environment addresses two classes of abilities particularly lacking in these individuals. The first class of abilities targeted is social skills. These individuals generally lack the elementary social skills that are required to build more sophisticated skills through social engagements. When these individuals interface with NT individuals, that lack of rudimentary social skills breaks down communication, which prevents deeper relationships and sophisticated social abilities from forming. This breakdown causes a great fear of failure and rejection when learning social skills through the standard channels. Since these individuals are already comfortable with computers, a computer-based intervention allows these individuals to learn social skills and explore mistakes in a familiar and non-threatening environment [18].

Besides the existing appeal and safety of technology, computer-based interventions, especially VR, utilize novel techniques that are impossible with classic interventions. One of these techniques is the ability for VR to induce pretense, or imagination, while experiencing the intervention. Immersive VR equipment induces the feeling and behavior of actually being in the environment [9, 10]. VE interventions that provide a high level of presence to the subject utilize pretense to enable generalization of the social rules being learned, which is usually difficult for individuals with ASD. VEs induce pretense by requiring the user to imagine the environment as a location in order to successfully navigate the VE [4]. If the VE is realistic, the user is able to use this pretense to link the environment to the real world, which increases the chance of generalizing the social skill to the real world [19].

This critical imagination, or pretense, is the second class of abilities that virtual environment are effective at targeting. An increased ability of pretense leads to a more sophisticated ToM, empathy, and perspective. Not only does the VE increase pretense during the intervention, which helps to generalize the targeted social skills, but Herrera et al. found that while administering VE, the VE increases the ability to use pretense after the experience [4]. Additionally, Colzato et al. have found that VEs administered to NTs improves cognitive flexibility outside of the intervention [20]. These studies suggest that the user's brain experiences functional plasticity, or forms new anatomical functionality, via rerouting while in the VE [21]. This functional plasticity not only improves the ability to generalize while in the VE, but also allows improvement of skills to be perpetuated outside of the VE.

Traditionally interventions have targeted teaching social rules [13, 15] or motivations for behavior [13] The individual being treated is asked to think about their social rule set or possible motivations before socially interacting. Although these are the standard ways to teach individuals with ASD social skills, it is not the way NT individuals learn. A NT individual uses pretense and ToM to implicitly imagine how their actions are viewed by others and this directs their social norms [4]. If pretense can be induced in a person with ASD with lasting effects, a more effective ToM may be developed directing the social norms naturally. A VE intervention that induces an effective pretense will be especially effective at improving social interactions for individuals with ASD.

One cause of the lack of ToM in individuals with ASD stems from the individual's lack of imagination [22, 23]. It is very difficult for these individuals to imagine the perspective of others or to think in third-person. By inducing a role-play scenario on the computer, individuals with ASD can imagine other points of view and develop this for use outside of the intervention. While the individual associates with the in-game avatar, they are projecting their mind onto the avatar; it is just another step for them to project their mind on a real individual. Increasing presence within a VE increases the association the individual feels within the environment so this dissertation explores the extent to which increasing illumination realism changes the sense of presence within a VE. The theory states that the more presence the individual feels, the closer they are to mapping their mind onto a real individual or thinking about themselves in the third-person. The more presence the VE induces automatically, the more the individual imagines subconsciously. Therefore, the individual requires less intentional imagination (mental imagery [24]) to think of the environment as real. If we can induce pretense while the user is experiencing strong presence, the user can learn as a NT individual does since it's similar to using pretense to learn in the real-world, including the same emotions, except for the fear of failure. By closing this gap, we hope to use the imaginations induced by the VE to teach the student social skills during the intervention through an improved ability to generalize. While previous work focused on lighting realism [6], in this study we focused on display technology, namely a new HMD, the Oculus Rift, which was recently released to developers [12]. Figure S1-S1 shows this paper's coauthor, James Munger, using the Oculus Rift. A HMD, which is a device that fits over the face that displays stereoscopic video close to each eye, is much more immersive than a traditional display because it provides stereopsis and motion detection to allow the user to look around, which usually causes a user to feel that they really are "there."

While there are many studies [20, 25, 26] that suggest that HMDs are a fantastic medium for teaching neurotypicals due to providing a feeling of this presence, we found one case study (n=2) [2] appearing in 1996 that involved cumbersome and old technology. There were other problems with these first-generation HMDs including poor viewing angle, which limits what the user can see; latency, which affects how accurately the device follows head movement; and eyestrain, which is caused by staring at a screen which does not have true depth. The results of this study [2] were non-conclusive and it seems that researchers have somewhat written off the technology as too expensive, difficult to use, and intrusive to the user to be an effective tool for an intervention. While it's true that the old HMDs were massive, heavy, and displayed output that was similar to looking through a distant window, the Oculus Rift is a revolutionary display that provides greatly improved stereopsis, a high frame rate (60fps), low latency between head tracking and display, and a high viewing angle providing a realistic peripheral view (110 deg), all of which have been shown to be associated with higher levels of reported presence by neurotypicals [27–31]. This, along with its low weight and low cost ($300), makes the HMD an interesting tool for use in an intervention.

3 Methodology

3.1 Creating the Virtual Environment

The VE was written in C# using the Microsoft XNA [32] and Sunburn Frameworks [33]. The Sunburn framework, provided by Synapse Gaming, provides tools to create, view, and manipulate 3D VE. It also provides support for viewing VE using the Oculus Rift. Microsoft XNA is a set of tools for video game development and management, provided by Microsoft.

VEs are traditionally experienced as a single image in 2D on a flat screen but the Oculus Rift requires a separate and different view for each eye to provide stereoscopic 3D. The Sunburn framework provides a method for converting a single view into the two required views for the Oculus Rift. The two views must be warped to fit together to create a single 3D view to the user. When viewing the VE on a traditional monitor display you will see two 2D images side by side. Three different scenes were created, each with three tasks (explained below) assigned. A scene is a particular 3D environment where the subject can interact. Figure S1-S5 shows the first scene as seen in 2D, although when viewed using the HMD you will perceive one stereoscopic 3D scene. It is truly an effect that can only be fully appreciated firsthand.

The scenes that were created for this test are designed to be very simple. Only a few models were used in each scene, and the scenes utilize simple ambient light with no shadows. Future tests could be conducted, introducing more realism by adding realistic lighting and shadows, to see if these variables have any effect on the subject's presence when compared to their absence.

3.2 Designing the Group Study

The test consists of three simple tasks, which were designed and created with the knowledge that students in an elementary school would complete them. The activities chosen were modeled from activities that were demonstrated in previous studies to be activities that subjects with learning disabilities could generally complete successfully using traditional desktop displays. In this way any difficulties faced by the group composed of those with learning disabilities, yet not faced by the group composed of neurotypicals, could be explained by inherent differences in the way these subjects experience HMDs. In the first test the subject was placed in a grassy park surrounded by brick walls with a purple picnic table in the distance. The subjects were instructed to move to the purple picnic table by pushing forward on the left analog stick of the controller (figure S1-S2). In the second test, the subject was placed in a similar area that contained maze-like brick walls (figure S1-S3). The instructions provided were to locate and move to the green car. In the final test, the subject was placed in a similar area with a traffic-filled road in the distance (figure S1-S4). The goal in this test was to move to the road, look both ways, and cross when the traffic had stopped. Each subject was given two minutes to complete each task. Two metrics were obtained, a score, which determines the subject's ability to complete each task and a survey to obtain the subject's feeling of presence during the test. If using VR increases presence, then it may be a more effective method than traditional monitor displays.

First, the participants were introduced to the Oculus Rift HMD and allowed to look at and feel the device. Figure S1-S5 is an image of the Oculus Rift. They were then shown the dual analog controller, which would allow them to provide input for the test. Figure S1-S6 shows the dual analog controller used in the testing. Each subject decided, at this point, whether or not they were willing to wear the Oculus Rift. In the past, HMD's were more intimidating, so it was important to judge each subject's willingness to wear the device.

The subjects were informed that they would have to complete three tests with instructions provided verbally by the researcher. Non-verbal subjects with ASD were also shown flash cards of their tasks, one example of which is shown in figure S1-S7. As each subject completed their task a score between one and three was recorded based on their success. This score is based on a the completion of three tasks per scene (one point per task), and the score is weighted depending on which scene they are solving, with the first weighted at 1x, the second weighted at 2x, and the third scene weighted at 3x, for a total of eighteen possible points. For instance, completing the task of looking both ways in scene three is weighted at 3x so is worth three points. Figure S1-S8 lists the evaluation form with the point values.

Each subject was also asked two questions after each task: "Did the experience look real to you?", and "Did the experience feel real to you?" These questions were based on Slater's suggestion for a Likert scale [34, 35], but tailored to suit those with ASD. A previous study [36] found that pure Likert scales were too abstract for many subjects with ASD to conceptualize. For instance, a midrange response was rarely received; instead the answers were usually extreme. Therefore we utilized discrete multiple-choice questions instead of a scale. Answers were recorded as either very real, real, not very real, and not real at all. The question "To what extent do individuals with ASD feel presence while using the HMD when compared to neurotypicals?" was answered by using this scale, which is similar to what Slater [10] uses in his studies. The question sheet is listed in figure S1-S9.

4 Evaluation

4.1 Data

Data was collected from nineteen subjects, which is shown in table 1. Eight of the subjects had ASD and the remaining eleven were neurotypical. Of the eight subjects with ASD, two were low-functioning non-verbal on the ASD spectrum, one was low-functioning but verbal, four were high-functioning verbal on the ASD spectrum, and one had a Sotos Syndrome (related to ASD). It is important to note that none of the low functioning non-verbal subjects were able to complete any of the tasks. Of these three, two refused to wear the device and one was willing but unable to follow the directions given.

Collected Data				
Subject Group	**Gender**	**Age**	**Evaluation Score**	**Presence Survey Average**
ASD(low-functioning non-verbal)	M	5	-*	NA
ASD(low-functioning verbal)	F	7	0	NA
ASD(low-functioning non-verbal)	M	7	-*	NA
ASD(high-functioning verbal)	F	6	12	1.00
ASD(high-functioning verbal)	M	6	12	1.00
ASD(high-functioning verbal)	M	8	18	2.00
ASD(high-functioning verbal)	M	7	12	NA
Learning Disability (sotos syndrome)	M	7	9	NA
Neurotypical	F	5	15	1.00
Neurotypical	F	7	18	1.00
Neurotypical	F	7	18	1.67
Neurotypical	M	5	18	1.50
Neurotypical	M	6	15	1.00
Neurotypical	M	7	15	1.50
Neurotypical	M	7	18	1.50
Neurotypical	M	7	18	2.50
Neurotypical	M	7	18	2.83
Neurotypical	M	8	18	1.67

Neurotypical	M	9	18	1.83

* - refers to the subjects who refused to wear the HMD

Table 1. Raw Collected Data

4.2 Data Analysis

Each subject received an evaluation score of 0 to 18 depending on their successful completion of tasks in the VE. The null hypothesis states that the two groups performed equally, while the alternative hypothesis states that the two groups perform differently. Due to the low numbers of participants, we chose to use the Mann-Whitney U-Test and found the one-tailed p-value to be 0.01, so we reject the null hypothesis that ASD>=N.

The presence survey score reflects the subject's presence in the VE. Using a 4-point Likert scale (with choices represented with discrete answers, see above), each subject was asked if what they saw looked real and if what they experienced felt real with 1 representing very real and 4 representing not so real. Unfortunately only three participants in the group with learning disabilities responded to the presence survey, which was based upon verbal feedback. Testing those three against the eleven neurotypicals, we found the one-tailed p-value to be 0.28, so we do not reject the null hypothesis that ASD>=N. The number of subjects responding is simply too low to make a valid comparison.

Statistical Data								
Category	U	P-value (one-tailed)	ASD n	ASD $\bar{x}$	ASD σ	N n	N $\bar{x}$	N σ
Evaluation Score	48	0.01	5	12.60	3.29	11	17.18	1.40
Presence Survey	21	0.28	3	8.00	3.46	11	9.82	3.54

*(ASD=group with learning disabilities, N=group of neurotypicals

Table 2. Statistical Data

4.3 Qualitative Observations

While the level of presence cannot be compared between those with ASD and those neurotypicals, the subjects in both groups were very enthusiastic about using the HMDs. Most of them readily took to the controller, whose button mapping was based upon standard game console gamepad button mapping [37]. All of the subjects who tried it seemed to have positive experiences and acted excited to be using a HMD. Of those with ASD with verbal skills, we had comments such as "I want to keep playing!", "It's just like my PlayStation!", "It feels very real", and "It was really fun!"

Unfortunately two of the low functioning subjects with ASD did not want to wear the device so did not complete the study. The teacher of these subjects informed us that one of these subjects was not willing to wear earphones or anything on his head. The data for these subjects were not used for the statistical analysis, but it's important to note that HMDs are not appropriate for some children low on the spectrum.

We tested one non-verbal subject with a learning disability who was able to use some basic sign language to communicate. During the first test, he was able to travel to the picnic table in a straight line with no problem. After the first test, he removed the HMD and excitedly signed something to the teaching aide. She informed us that he was asking if there was more. We continued to the second test, which requires moving in different directions and maneuvering to find a green car. After we gave him the directions, he was having trouble manipulating the controls, and he set the controller down on the table. We received feedback from the subject to the aide via sign language. The controller was handed to him again and he was able to complete the second test.

We also tested a low functioning nonverbal subject with ASD who was willing to wear the HMD but was unable to manipulate the controller at the same time. He was very interested in viewing the VE through the device and was looking around in every direction, seemingly fascinated by the immersive environment.

4.4 Evaluation of the Analysis

The question as to whether subjects with ASD can perform tests just as well as those neurotypicals using a HMD was shown to be false: those with ASD did not perform as well on our tests as neurotypicals. Even so, most still accepted the HMD and reached the goals of over half of the tasks assigned. Further, the qualitative feedback from the children demonstrated that most of the subjects were excited to use the technology and so we believe that the HMD is still a promising tool to treat those with ASD.

There wasn't enough data to answer the question as to what extent those with ASD experience presence differently than those neurotypicals. Even so, the excited feedback suggested to us that the technology was inducing a sophisticated level of presence in these children, so it would be interesting to see the results of a larger study.

5 Conclusion

Although this study was limited, it provided evidence that those with ASD are not as capable at following instructions while using a HMD as their neurotypicals peers. Even so, a number of those with ASD did complete the majority of the tasks so HMDs still hold promise as a tool for interventions and this study is useful as a feasibility test. The previous experiments with HMD's and ASD were unsuccessful to the point that the idea was shelved and labeled a dead end[2]. Now, with the Oculus Rift as an affordable and effective alternative HMD, combined with the results of this study, it is time to seriously research further applications. This device is more affordable for teachers and therapists, and it seems to be an exciting tool for simulating otherwise difficult situations.

Unfortunately, due to the limited number of participants, no conclusions can be reached concerning the presence experienced while using the HMD when comparing with those with ASD and those neurotypicals. Even so, the qualitative evidence demonstrates that the subjects with ASD did have an experience that led to a sophisticated level of presence. The result of this study allows more questions to be asked, all of which can now be researched. Previous studies have shown how immersive VR can be, and also that immersion increases the effectiveness of learning. [2][6] Now the remaining work is to find which interventions are most effective with the Oculus Rift.

While we have found that those with ASD accomplished fewer of the tasks than those with neurotypicals, it is not enough to reach a conclusion about the validity of HMDs. Further, more data should be gathered from subjects focused on the upper and lower ends of the ASD spectrum and a larger number of subjects should be used. Those with Autism were still able to complete certain tasks, and did so enthusiastically. The next stage of the work should concentrate on comparing the efficacy of HMDs with that of standard, evidence-based practices. For instance, it may be interesting to implement AViSSS [36] on the HMD and compare the outcome with AViSSS on a standard desktop display.

6 Bibliography

1. Strickland, D.C., McAllister, D., Coles, C.D., Osborne, S.: An Evolution of Virtual Reality Training Designs for Children With Autism and Fetal Alcohol Spectrum Disorders. Top Lang Disord. 27, 226–241 (2007).
2. Strickland, D., Marcus, L.M.: Brief report: Two case studies using virtual reality as a learning tool for autistic children. J. Autism Dev. Disord. 26, 651–659 (1996).
3. Moore, D., Cheng, Y., McGrath, P.: Collaborative virtual environment technology for people with autism. Focus Autism. (2005).
4. Herrera, G., Alcantud, F., Jordan, R., Blanquer, A., Labajo, G., De Pablo, C.: Development of symbolic play through the use of virtual reality tools in children with autistic spectrum disorders: Two case studies. Autism Int. J. Res. Pract. 12, 143–157 (2008).
5. Parsons, S., Mitchell, P., Leonard, A.: Do adolescents with autistic spectrum disorders adhere to social conventions in virtual environments? Autism. 9, 95 (2005).
6. Ehrlich, J.: The Effect of Global Illumination on Presence in a Virtual Environment for those with Autism Spectrum Disorder. Presented at the The 2011 International Conference on Computer Graphics and Virtual Reality Conference , Las Vegas, NV July (2011).
7. Schmidt, C., Schmidt, M.: Three-dimensional virtual learning environments for mediating social skills acquisition among individuals with autism spectrum disorders. Proceedings of the 7th international conference on Interaction design and children. pp. 85–88. ACM, New York, NY, USA (2008).
8. Mitchell, P., Parsons, S., Leonard, A.: Using Virtual Environments for Teaching Social Understanding to 6 Adolescents with Autistic Spectrum Disorders. J. Autism Dev. Disord. 37, 589–600 (2007).
9. Slater, M.: Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. Philos. Trans. R. Soc. B Biol. Sci. 364, 3549–3557 (2009).
10. Slater, M., Khanna, P., Mortensen, J., Yu, I.: Visual Realism Enhances Realistic Response in an Immersive Virtual Environment. IEEE Comput. Graph. Appl. 29, 76–84 (2009).
11. Ehrlich, J.A.: The effect of desktop illumination realism on a user's sense of presence in a virtual learning environment, (2010).
12. Rift, http://www.oculusvr.com/rift/.
13. Sicile-Kira, C.: Autism spectrum disorders : the complete guide to understanding autism, Asperger's syndrome, pervasive developmental disorder, and other ASDs. Berkeley Pub. Group, New York (2004).
14. Skinner, B.F.: The behavior of organisms. Appleton-Century-Crofts, New York, (1938).
15. Exkorn, K.S.: The autism sourcebook : everything you need to know about diagnosis, treatment, coping, and healing. ReaganBooks, New York (2005).
16. Tager-Flusberg, H., Caronna, E.: Language disorders: autism and other pervasive developmental disorders. Pediatr Clin North Am. 54, 469–81, vi (2007).

17. Gray, C., White, A.L., McAndrew, S.: My social stories book. Jessica Kingsley Publishers, London ; Philadelphia (2002).
18. Burne, J.: Say It Loud, Autistic and Proud, http://www.guardian.co.uk/lifeandstyle/2005/nov/13/healthandwellbeing.health/print, (2005).
19. Alexander, H.G.: A Suggestion Concerning Empirical Foundations of Imagination. Philos. Phenomenol. Res. 23, 427–431 (1963).
20. Colzato, L.S., van Leeuwen, P.J.A., van den Wildenberg, W.P.M., Hommel, B.: DOOM'd to switch: superior cognitive flexibility in players of first person shooter games. Front. Cogn. 1, (2010).
21. Zimmerman, A.W., Gordon, B.: Neural Mechanisms In Autism. Core Deficit Autism Disord. Relat. Commun. 5, 119–132 (2001).
22. Leslie, A.M.: Pretense and Representation: The Origins of "Theory of Mind." Psychol. Rev. 94, 412–426 (1987).
23. Frith, U.: Autism : explaining the enigma. Basil Blackwell, Oxford, UK ; Cambridge, MA, USA (1989).
24. Thomas, N.J.T.: Mental Imagery. In: Zalta, E.N. (ed.) The Stanford Encyclopedia of Philosophy (2014).
25. Bergeron, B.: Developing Serious Games (Game Development Series). (2006).
26. Ai-Lim Lee, E., Wong, K.W., Fung, C.C.: How Does Desktop Virtual Reality Enhance Learning Outcomes? A Structural Equation Modeling Approach. Comput. Educ. (2010).
27. Claudia M. Hendrix, W.B.: Presence Within Virtual Environments as a Function of Visual Display Parameters. Presence. 5, 274–289 (1996).
28. Meehan, M., Insko, B., Whitton, M., Frederick P Brooks, J.: Physiological Measures of Presence in Virtual Environments. University of North Carolina at Chapel Hill (2001).
29. Meehan, M., Razzaque, S., Whitton, M.C., Brooks, J., F.P.: Effect of latency on presence in stressful virtual environments. IEEE Virtual Reality, 2003. Proceedings. pp. 141–148 (2003).
30. Barfield, W., Hendrix, C., Bystrom, K.-E.: Effects of Stereopsis and Head Tracking on Performance Using Desktop Virtual Environment Displays. Presence Teleoperators Virtual Environ. 8, 237–240 (1999).
31. Ijsselsteijn, W., Ridder, H.D., Freeman, J., Avons, S.E., Bouwhuis, D.: Effects of Stereoscopic Presentation, Image Motion, and Screen Size on Subjective and . . . (2001).
32. Getting Started with XNA Game Studio Development, http://msdn.microsoft.com/en-us/library/bb203894.aspx.
33. Free SunBurn Platform Framework for C# / .Net / Mono - Synapse Gaming, https://www.synapsegaming.com/products/sunburn/framework/.
34. Slater, M., Steed, A., McCarthy, J., Maringelli, F.: The influence of body movement on subjective presence in virtual environments.(Special Section: Virtual Environments: Models, Methodology, and Empirical Studies). Hum. Factors. 40, 469(9) (1998).
35. Slater, M.: Measuring Presence: A Response to the Witmer and Singer Presence Questionnaire. Presence Teleoper Virtual Env. 8, 560–565 (1999).
36. Ehrlich, J.A., Miller, J.R.: A Virtual Environment for Teaching Social Skills: AViSSS. IEEE Comput Graph Appl. 29, 10–16 (2009).
37. Xbox360Controller - Unify Community Wiki, http://wiki.unity3d.com/index.php?title=Xbox360Controller.

Supplementary Materials:

Figures S1-S1. James Munger using the Oculus Rift

Figures S1-S2. Example view of the first scene, which is mean to be an introduction.

Figures S1-S3. Example view of the second scene, which is a maze-like level.

Figures S1-S4. Example view of the third scene, which has the cross-walk.

Figures S1-S5. The Oculus Rift, which is the next generation HMD.

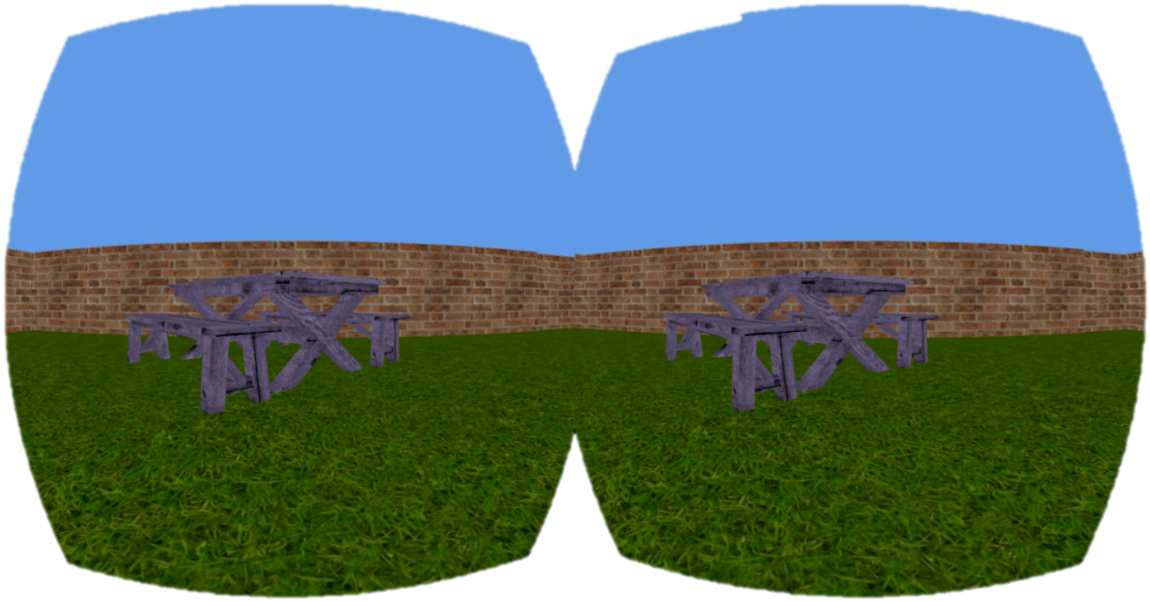
Figures S1-S6. The dual analog controller used to interact with the environment.

Figures S1-S7. Flash cards to communicate with those without verbal skills.

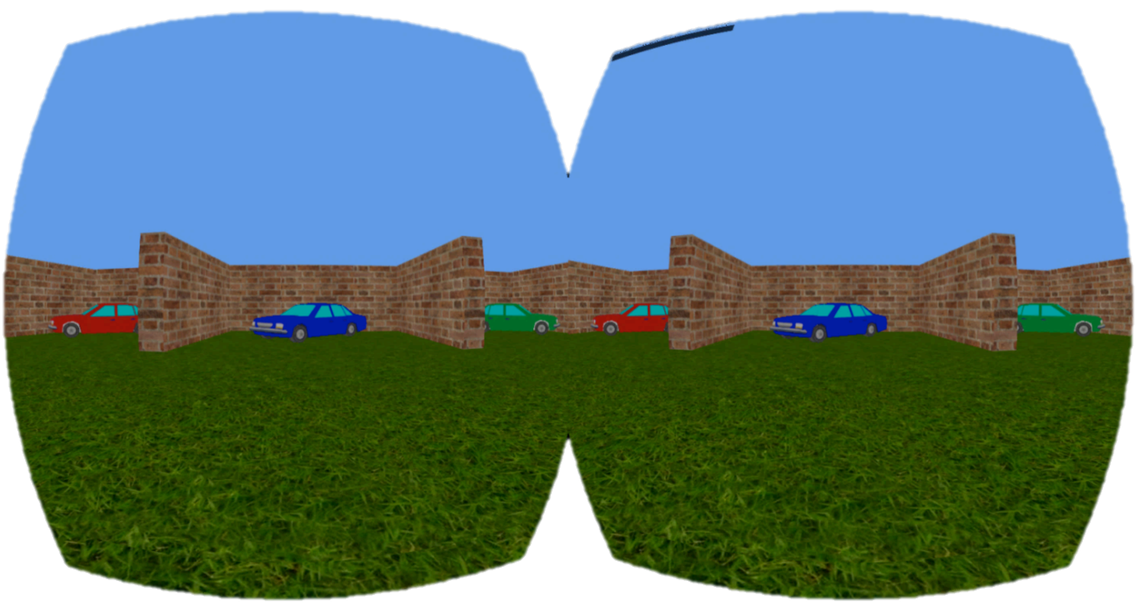
Figures S1-S8. The evaluation form for the researchers evaluating the subjects.

Figures S1-S9. The presence survey to determine the presence felt by the subjects.

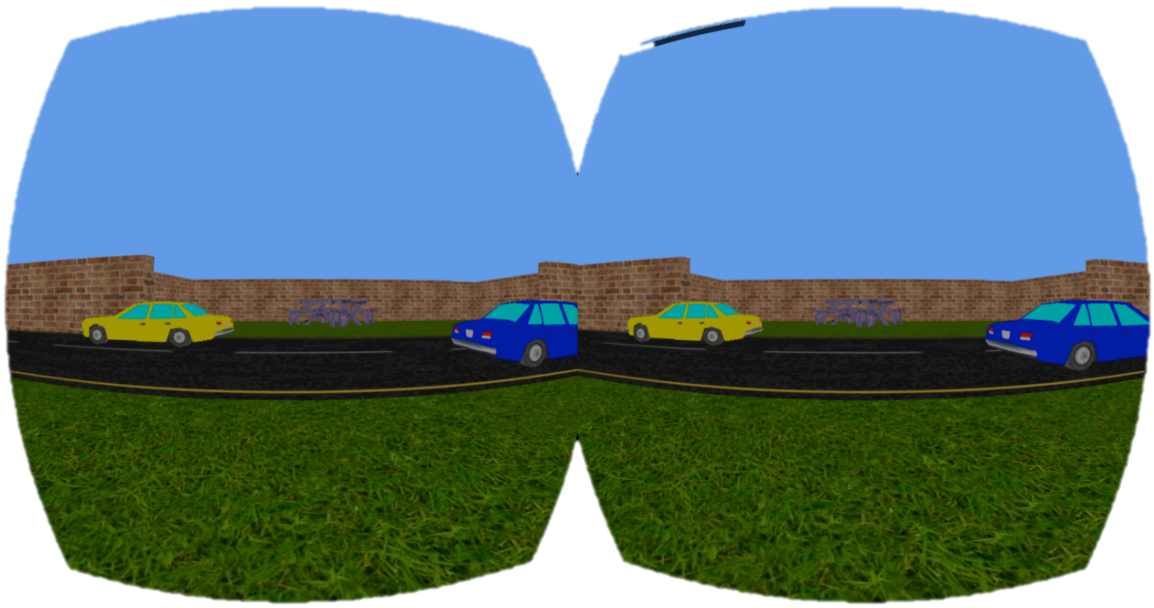
Figures S1-S1. James Munger using the Oculus Rift



Figures S1-S2. Example view of the first scene, which is mean to be an introduction.



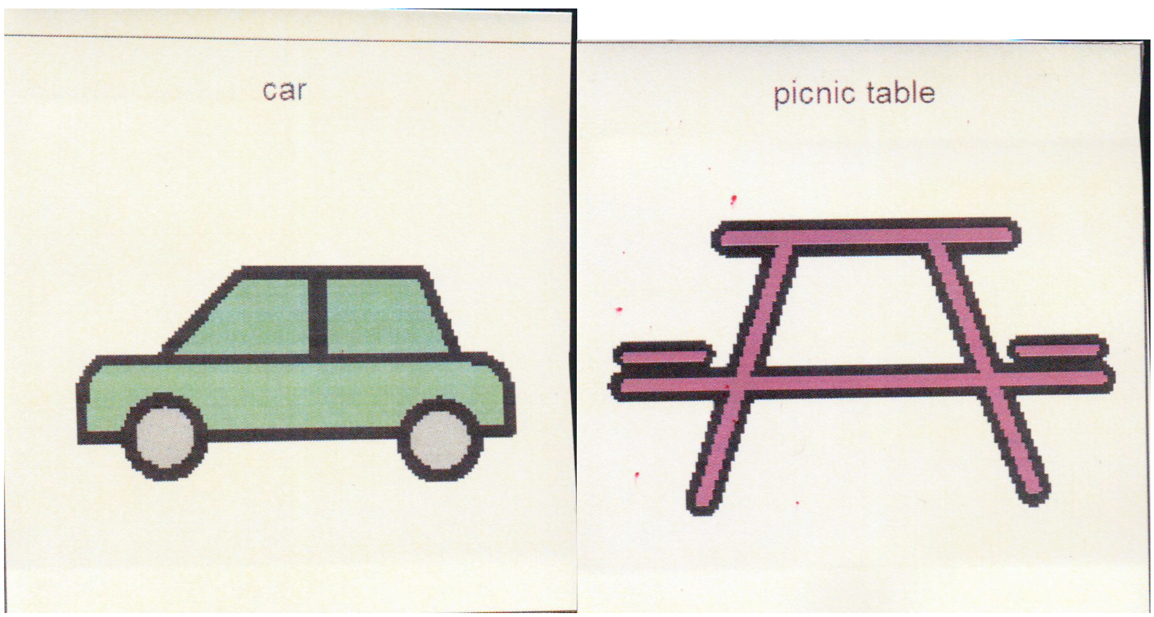
Figures S1-S3. Example view of the second scene, which is a maze-like level.



Figures S1-S4. Example view of the third scene.

Figures S1-S5. The Oculus Rift, which is the next generation of HMD.

Figures S1-S6. The dual analog controller used to interact with the environment.



Figures S1-S7. Flash cards to communicate with those without verbal skills.

Evaluation Form

<u>Scene A: (weighted at 1x)</u>

__1 Point: User walked in a direction towards the target
__1 Point: touched the correct target
__1 Point: User stopped at the correct target.

<u>Scene B (weighted at 2x)</u>

__1 Point: User Maneuvered around the wall
__1 Point: User touched the correct target
__1 Point: User stopped at the correct target.

<u>Scene C (weighted at 3x)</u>

__1 Point: stopping at the street
__1 point: looking both ways
__1 point: crossing the street after traffic has stopped

Notes:____

____

____

____

Figures S1-S8. The evaluation form for the researchers evaluating the subjects.

Reported Presence Questionnaire

1. What was your experience like in the first scene, walking to the picnic table?
   - It felt like it was real.
   - It usually felt like reality.
   - It usually did NOT feel real.
   - It never felt like reality.

2. What were your emotions like in the first scene, walking to the picnic table?
   - I felt the same as if it actually happened.
   - I sometimes felt the same as if it was real.
   - I rarely felt the same as if it was real.
   - I did not respond emotionally to the Scene.

3. What was your experience like in the second scene, finding the green car?
   - It felt like it was real.
   - It usually felt like reality.
   - It usually did NOT feel real.
   - It never felt like reality.

4. What were your emotions like in the second scene, finding the green car?
   - I felt the same as if it actually happened.
   - I sometimes felt the same as if it was real.
   - I rarely felt the same as if it was real.
   - I did not respond emotionally to the Scene.

5. What was your experience like in the third scene, waiting for traffic and crossing a street?
   - It felt like it was real.
   - It usually felt like reality.
   - It usually did NOT feel real.
   - It never felt like reality.

6. What were your emotions like in the third scene, waiting for traffic and crossing a street?
   - I felt the same as if it actually happened.
   - I sometimes felt the same as if it was real.
   - I rarely felt the same as if it was real.
   - I did not respond emotionally to the Scene.

Figures S1-S9. The presence survey to determine the presence felt by the subjects.

Category: Paper

Title: NFC LearnTracker: Seamless support for learning with mobile and sensor technology

Authors: Bernardo Tabuenca[1*], Marco Kalz[1], Marcus Specht[1]

Affiliations: [1]Welten Institute, Research Centre for Learning, Teaching and Technology. Open University of the Netherlands; Heerlen, The Netherlands

*Correspondence to: bernardo.tabuenca@ou.nl

Summary: A mobile tool for self-regulation of time with NFC tags and learning analytics.

Abstract: Lifelong learners' activities are scattered along the day, in different locations and making use of multiple devices. Most of the times they have to merge learning, work and everyday life making difficult to have an account on how much time is devoted to learning activities and learning goals. Learning experiences are disrupted and mobile seamless learning technology provides new solutions to integrate daily life activities and learning in the same process. Hence, there is a need to provide tools that are smoothly integrated into adults' daily life. This manuscript presents the NFC LearnTracker, a mobile tool proposing the user to immerse within his autobiography as a learner to identify successful physical learning environments, mark them with sensor tags, bind them to self-defined learning goals, keep track of the time invested on each goal with a natural interface, and monitor the learning analytics. This work implies a suitable tool for lifelong learners to bind scattered activities keeping them in a continuing learning flow. The NFC LearnTracker is released under open access licence with the aim to foster adaptation to further communities as well as to facilitate the extension to the increasing number of sensor and NFC tags existent in the market.

Main Text:

I. Introduction

Self-organized lifelong learning is one of the critical competences for individuals to cope with societal challenges and resulting changing demands on job markets. A survey by the European Commission has identified time, location and conflicts with other activities as the core barriers to lifelong learning [1]. Nowadays, lifelong learners are confronted with a broad range of activities they have to manage everyday. In most cases they have to combine learning activities and their professional and private life linking formal and non-formal learning activities. In the setting of an adult lifelong learner this is especially difficult as in most cases interests might be highly distributed over different domains and keeping up learning needs an extra effort. One of the main challenges here is the bridging of learning activities between different contexts.

Mobile seamless learning technology can offer solutions to address this problem. Seamless learning was first defined as a learning style where a learner can learn in a variety of scenarios and in which they can switch from one scenario or context to another easily and quickly, with the personal device as a mediator [2]. Succeeding, Wong et al. [3] identified ten gaps in seamless learning support: 1) Encompassing formal and informal learning; 2) Encompassing personalized and social learning; 3) Across time; 4) Across locations; 5) Ubiquitous knowledge access; 6) Encompassing physical and digital worlds; 7) Combined use of multiple device types; 8) Seamless switching between multiple learning tasks; 9) Knowledge synthesis; 10) Encompassing multiple pedagogical or learning activity models. Lately, a learner-centric view of mobile seamless learning [4] suggests that *a seamless learner should be able to explore, identify and seize boundless latent opportunities that his daily living spaces may offer to him (mediated by technology), rather than always being inhibited by externally-defined learning goals and resources*. For lifelong learners several key aspects have to be highlighted that are essential problems:

- No support for learning activities across locations, devices, and environments. There is very little research on how to link the different everyday contexts of lifelong learners and their learning activities in these different settings. (Seam 3, 4)

- Linking learning activities with everyday life activities and the physical world objects. Everyday life events trigger different activities that lead to learning events. The linking between the self-directed learning of lifelong learners and their everyday environment is not foreseen in todays learning technology (Seam 1, 2, 7, 8)
- Supporting reflection on learning activities and personal project in heterogeneous environments making use of different technologies (Seam 6, 9, 10).

In summary there is little support for lifelong learners that typically try to learn in different contexts, are busy with multiple parallel learning tracks, and must align or relate their learning activities to everyday leisure and working activities. Candy [5] has summarized four components of self-directed lifelong learning. These are self-*monitoring*, *self-awareness*, *self-management* (planning of learning) and last but not least *meta-learning*. To date, there is little technological support to enable learners in conducting these different activities across contexts and locations. A recent survey to lifelong learners on mobile usage habits reveals that there is an association between the type of learning activity being performed (read, write, listen, watch) and the concrete location where it takes place [6]. Hence, there is a need to provide suitable tools for lifelong learners to facilitate bridging learning experiences in a seamless flow. In this paper Near Field Communication (NFC) is proposed as an instantiation for natural interaction with mobile devices and for seamless integration of technology in lifelong learning. The following section reviews previous research of scientific work where NFC has been used with learning purposes. Section 2 identifies the four pillars sustaining the design of a mobile tool for self-regulated support: the NFC LearnTracker. In section 3 the core features are described and the results of a prototype formative evaluation are presented. Finally, conclusions are discussed and future work is described.

A. Using NFC sensor tags for bridging seams and natural interaction

Natural User Interfaces and the *Internet of Things* have been predicted to have an impact on education in the short term [7]. Tagged objects are widely accepted and the number of connected devices could reach 50 billion by 2020 [8]. Different tagging methods (e.g. visual codes, text recognition, image recognition) allow enriching physical objects of the world with educational resources [9]. Moreover, the prominent adoption of NFC readers in mobile devices has moved this technology from an innovator to an early adopter phase. This frictionless technology will enrich our environment facilitating natural interactions with daily physical objects. NFC simplifies and reduces several actions to a single action of narrow contact (zero click overhead). These small exchanges of information between devices that occur almost instantaneously have been recently coined as *micro-interactions* [10].

Recent work [11], presents some of the potentials NFC technology brings for teaching and learning materials in formal education: distributing learning/teaching materials in face-to-face classrooms; enriching printed materials; sharing materials among students; delivery of practicals; integration of social networks; access to control materials; examinations. Likewise, there is an increasing number of empirical studies using NFC technology in field trip excursions [12], [13], connecting digital and physical worlds [14]–[16] or combining this technology within Learning Management Systems [17]. Nevertheless, NFC has not been used to tackle the problems of lifelong learners. In the following we will frame and integrate these approaches according to the model of Candy [5] introduced in section 1.

II. Design of the NFC LearnTracker

The NFC LearnTracker is a standalone application developed for NFC-enabled Android (4.03 or above) devices released in March 2014 in Google Play[1]. The NFC LearnTracker uses an embedded database for local/client storage in the same application software to avoid privacy issues. The NFC LearnTracker project has been released trusting open code license available in an open source repository[2] to be downloaded, customized and further extended to different learning environments, LMSs, or communities. This section presents the NFC LearnTracker as mobile seamless tool for developing self-regulated learning that aims to cover the following gaps in lifelong learners' learning process:

[1] NFC LearnTracker in Google Play.
https://play.google.com/store/apps/details?id=org.ounl.lifelonglearninghub
[2] Lifelong Learning Hub's code repository. https://code.google.com/p/lifelong-learning-hub/

1. No support for learning activities across locations, devices and environments.
2. No linking between learning activities and everyday life.
3. No feedback on lifelong learning activities.

The NFC LearnTracker has been designed based on the seamless notion that lifelong learners can learn in a variety of scenarios and can switch from one scenario or context to another easily and quickly, using the personal device as a mediator. Figure 1 illustrates how daily life activities and learning activities are combined in a continuing process. The tool presented in this section has been conceptualized on the idea that mobile technology can be smoothly integrated in daily life activities whenever interacting with it requires the least number of clicks (zero) possible and the duration of any action with the tool lasts not longer than 20 seconds.
Butler and Winne [18] describe the self-regulated learning model as an iterative process comprising four sequential stages: 1) interpretation of own learning paths and task queuing; 2) cognitive process of defining goals and monitoring the progress; 3) perform the learning activity; 4) interpretation of external feedback. Focusing on lifelong learners, Candy [5] proposes a learner-centric model with four stages (See section 1). Hereby we describe in a narrative way [19] how these stages have been covered with the NFC LearnTracker using the scenario of Miguel Angel, a PhD student aiming to combine daily life activity (family, work, leisure) with learning activities towards the accomplishment of his doctoral degree.

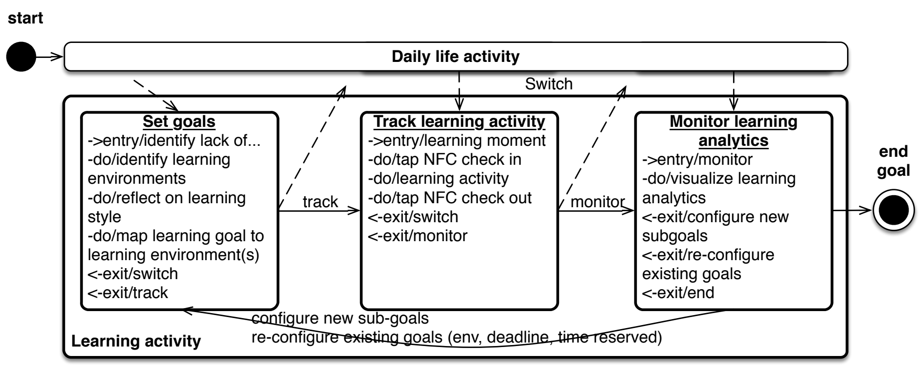
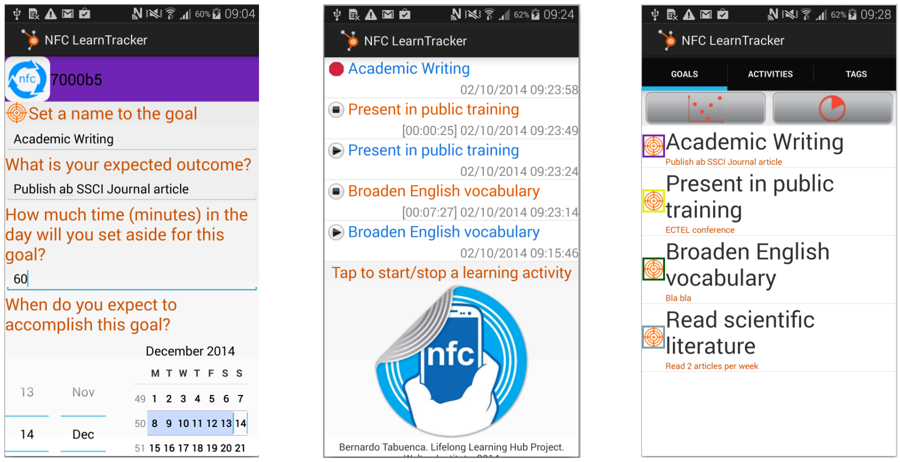


Figure 1. Lifelong Learning goal's life cycle. UML state diagram

A. Set goals.

Miguel Angel knows he needs to improve his academic writing, develop his skills to make effective presentations in public, broaden his English vocabulary, and set aside time to read scientific literature. As he engages in these learning tasks, he draws on knowledge and beliefs constructing an interpretation of each task´s properties and requirements [18]. In fact, Miguel Angel frequently introspects his autobiography as a learner to identify which learning environment fits better to which learning task upon his learning style or time availability [20]. This stage (fig.1) covers the "*Planning for learning*" and "*self awareness"* stages in the self-regulation model for lifelong learners [5]. Analogously, Butler and Winne [18] situate the stage of "*setting goals*" within the cognitive system stressing its key importance in shaping the process of self-regulated learning.
In this stage (first box in figure 1), Miguel Angel reflects on his learning style mapping learning goals to frequently used learning environments and tagging them with NFC tags (See use cases in figure 3). Whenever Miguel Angel configures his goals in NFC LearnTracker, he takes a NFC tag, taps it with the NFC enabled mobile device so that the interface in figure 2A is displayed. He characterizes the goal with a name, specifies the expected outcome when he accomplishes the goal, foresees how much time (in minutes) will he devote to this goal on daily basis, and finally indicates his expected date to finish the goal. Sticking a NFC tag on a physical learning object enables the connection of a variety of tracking data with the learning activity. For example the "check-in" at a NFC tag (fig. 3B) can track Miguel´s use of a specific resource (i.e. tablet, book, laptop), at a certain time of the day, or, in a specific location (i.e. work, home).



A. Linking a purple NFC tag to *Academic Writing* learning goal

B. "Check-in" registered for *Academic Writing* and preceding learning event history

C. Learning goals configured by the user

Figure 2. Binding goals to NFC-tagged learning environments with NFC LearnTracker

B. Perform learning activity.

Miguel Angel, as most of the lifelong learners [6], recurs to specific locations (e.g. desktop, coach) and moments (e.g. waiting times, transitions) to accomplish his learning activities. In addition, Miguel Angel is interested to know how much time he devotes to his own learning goals during the day and along the week. Hence, Miguel needs a tool with natural interaction, otherwise he will not bother to track short learning moments (e.g. fifteen minutes writing, fig. 3A; twenty minutes reading, fig. 3B; ten minutes listening podcasts, fig. 3C; three minutes watching videos, fig. 3D), and as result it will never be accounted as learning time. Both self-regulation models [5], [18] situate this stage out of the scope of the cognitive system.

In this stage (second box in figure 1) Miguel Angel taps the associated NFC-tag every time he starts/stops a learning activity (fig. 2B). Hence, the NFC LearnTracker harvests all learning moments accounting them as real learning time with frictionless interactions.

A. Write two paragraphs for a journal article taking the first coffee

B. Reading scientific literature during waiting times

C. Listening english podcasts commuting to work, college, gym…

D. Watch top presenters' videos during commercial breaks

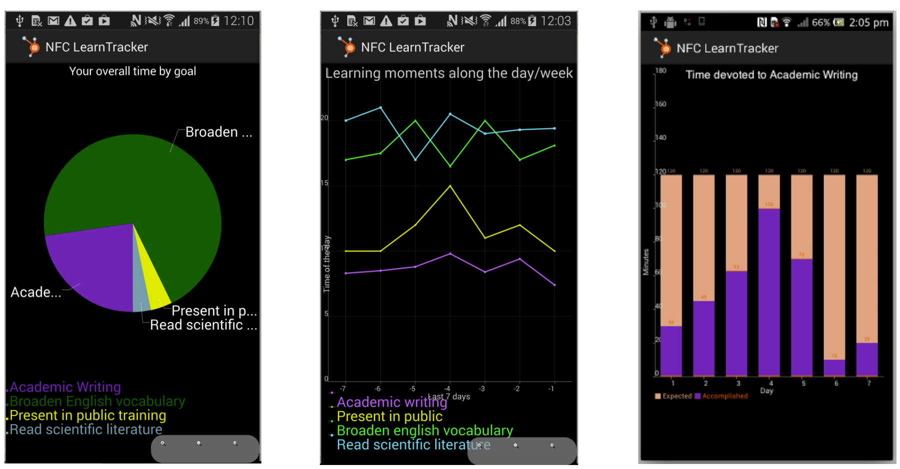
Figure 3. Learning activities (write, read, listen, watch) bound to daily learning environments

C. Monitor learning activities.

The NFC LearnTracker features learning analytics when defined as "*the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs*" [21]. Monitoring the state in learning activity can motivate the user towards the accomplishment of a learning goal. By comparing evolving states of a task to goals creates conditional knowledge that is the basis for further action. This cognitive process has been defined as "*internal feedback*" [18], "*self* *monitoring*", and "*understanding how to learn*" [5] in the previously cited self-regulation models. The cues identified by the user in this process facilitate the recognition of his learning patterns and as a result, the constant update of his autobiography as a learner.

In this stage (third box in figure 1), Miguel Angel can monitor his learning analytics for a specific goal, or as overall performance. Siemens [22] stressed that the focus of learning analytics is exclusively on the learning process. Hence, the NFC LearnTracker tracks and visualizes data about the learning process within the specific personal learning context for which they were configured by the lifelong learner, and independently from the content (subject, topic, etc.) that is learned in the process. The NFC LearnTracker features the following visualizations with the aim to foster understanding on learning habits, optimise learning, and, bind successful learning environments:

1. *Percentage of time invested on each learning goal*. Learning activities are scattered along the day in different locations or transitions. This feature provides lifelong learners an overall summary on how much time is devoted to learning goals. Figure 4A illustrates how percentage of total time and number of minutes are presented in a pie chart. This visualization can be used by lifelong learners to compare time invested on his learning goals, identify priorities to accomplish goals, and, patterns regarding preferences for specific learning environments, devices or learning activities (read, watch, write, listen).
2. *Distribution of learning moments along the day*. Every lifelong learners performs differently in the sense that some of us prefer to do learning activities that require a higher cognitive load or concentration in early morning (scientific reading or writing), or do the ones that require least cognitive load (watch videos or dispatch emails) while sat on the couch at night during every commercial pause on TV. Lifelong learners are intrinsically interested to identify patterns in their learning experiences and scaffold their autobiography as a learner to better distribute learning activities in forthcoming goals. Figure 4B illustrates the distribution of the learning moments during the day (X axis 0..24) for a whole week (Y axis 1..7). Each spot (square, triangle, circle) identifies when the learning activity started.
3. *Monitoring accomplished goals*. Monitoring is of crucial importance in relation to the development as a self-regulated learner. Monitoring is the cognitive process that assesses states of progress to goals and generates feedback that can guide further action [18]. Figure 4C illustrates a representation of accomplished learning time versus expected time towards a learning goal NFC LearnTracker.



A. Quantity of time invested in learning goals (Percentage or overall time and number of minutes)

B. Distribution of learning moments along the day in the last 7 days

C. Foreseen learning time (orange) versus effective time invested (in purple) on *Academic Writing* in the week

Figure 4. Learning analytics in NFC LearnTracker

III. Formative evaluation

The NFC LearnTracker was presented in March 2014 within a workshop for 14 PhD students. The concept of lifelong learning and the scope of the research were introduced where the problems described in the introduction section of the current manuscript were enumerated. With this focus in mind, the tool was presented for 30 minutes as a potential solution to those problems providing practical examples, making a demo with physical learning environments where the tool can be applied and highlighting the natural interaction of the NFC micro-interactions. After that, participants filled in a questionnaire containing eight 5-likert-scale questions prompting the participants to reflect and rate the potential of the tool to: manage learning goals; foster awareness on preferred learning environments; integrate learning with daily life activities; learning activities across contexts; set aside time to learn on regular basis; adjust goals high enough to challenge, but not so high to frustrate you; set mini-goals along the way; overall rating of the mobile tool to define goals, set-aside time, bind goals to daily activities, keep track of time invested on each goal, and monitor these analytics.

Potentials of the tool	**SD**	**AVG**
Manage learning goals	0.84	3.36
Foster awareness on preferred learning environments	0.70	3.79
Integrate learning with daily life activities	0.61	3.29
Learn across contexts	0.78	3
Set aside time to learn on regular basis	1	3.07
Adjust goals high enough to challenge but not so high to frustrate you	1.12	3.21
Set mini-goal along the way	0.73	3.93
Overall rating	0.75	3.43

Table 1. Evaluation of the tool with 5-likert scale (5:"strongly agree", 1:"strongly disagree")

Finally an open discussion was proposed around the following two questions: (1) "*What kind of feedback do you find suitable to be provided with this tool?*". Tips for productive listening, writing or reading were highlighted as a potential feedback supplied in the form of pushed notifications. E.g. Participant#4 suggested that it might be interesting if she would receive a notification prompting to determine the learning goals before starting the lecture or suggesting tips for productive listening like taking notes or asserting. Participant#7 stressed that notifications prompting to reflect on what has been learned after accomplishing the learning activity could help to make knowledge more persistent. Participant#8 suggested that it would be interesting to rate my perceived productivity after a learning activity and correlate it with the time of the day, day of the week, duration of the task, type of device used or location where I accomplished the learning activity. Participant#3 suggested providing a notification when you should make a break.

A second question 2 proposed a discussion about (2) "*In which learning scenarios do you consider this tool can be applied?*". Participant#1 suggested extending the scope of the mobile tool from self-regulation to a scenario in formal education. "*Books in secondary school could be NFC-tagged so that the teachers could use this tool to get a grasp on which subjects do students invest more/less time in their homework*". Participant#9 stressed the importance of the tool for self-awareness "*this tool could help me to establish some limits to the time I invest in non-academic tasks versus the time I invest in academic tasks*". Participant#3 stated, "*Sometimes you are so tied up with concrete projects that you really need to stop, reflect and organize your learning goals. This tool can be not only used to organize your learning time but also any other daily life activity*". Upon all these statements, several participants pinpointed to the learning analytics illustrated in figure 4 as a very interesting feature to quantify your learning style and become aware of the time devoted to learning activities in long term.

IV. Conclusions and future work

The observations on the lifelong learning process indicate that typical learning activities of continuing and further education are poorly connected to the daily activities of the learners. There is no support for learning activities across locations, devices and environments and there is a need to provide customized feedback to lifelong learning activities. The tool presented in this manuscript represents an approach to these problems. Tracking when, where and how learning occurs along the day provides rich information to infer lifelong learner's owns habits. This paper reviews previous work on educational scenarios using NFC and four pillars for seamless support of lifelong learners are identified. The NFC LearnTracker has been presented and evaluated as a tool to lead lifelong learners towards a self-regulated process: fostering awareness on learning goals and learning moments; facilitating the user to keep track of learning time with a natural interface; fostering engagement and motivation on the task providing feedback with useful statistics. The Lifelong Learning Hub Project[3] has been released under open licences with the aim to foster its adaptation to further educational communities as well as to facilitate the extension to the increasing number of NFC tags existent in the market.

As limitations, the evaluation of this tool has been performed in an artificial context (Technology Enhanced Learning workshop). The NFC LearnTracker should be tested in longitudinal studies with personal mobile devices and in lifelong learning settings. A realistic scenario must contemplate that the single decision to start using the tool should be triggered by an intrinsic motivation from the user to explore his learning patterns rather than an externally imposed tool. The effects in self-regulation and intrusiveness of logging learning time and monitoring learning patterns should be explored in further research. This tool might be an interesting approach to determine whether students with more scattered and shorter learning moments are correlated with better or worst performance.

In further research, we will investigate the effects in self-regulation of self-defined internal feedback loops [23] via ambient learning displays [24], [25] based on the patterns identified with the NFC LearnTracker. Additionally, services coexisting in smart learning environments will be orchestrated to provide customized feedback based on the type of learning task being performed (read, write, listen or watch).

The contribution of this manuscript is presenting a tool for lifelong learners to bridge scattered personal learning environments in which learners can define personal ecologies and experience the interaction with such a system in long term typical lifelong learner settings. This research aims at giving an open, flexible and low-cost prototyping framework for defining and linking everyday learning activities to contexts, physical artefacts, everyday home media solutions, and supporting to link sustainable learner tracks to these components.

References and Notes:

[1] Eurostat, "Lifelong Learning Statistics," 2012.

[2] T.-W. Chan, J. Roschelle, S. Hsi, M. Sharples, T. Brown, C. Patton, J. Cherniavsky, R. Pea, C. Norris, E. Soloway, N. Balacheff, M. Scardamalia, P. Dillenbourg, C.-K. Looi, M. Milrad, and U. Hoppe, "One-To-One Technology-Enhanced Learning: an Opportunity for Global Research Collaboration," *Res. Pract. Technol. Enhanc. Learn.*, vol. 01, no. 01, pp. 3–29, Mar. 2006.

[3] L.-H. Wong and C.-K. Looi, "What seams do we remove in mobile-assisted seamless learning? A critical review of the literature," *Comput. Educ.*, vol. 57, no. 4, pp. 2364–2381, Dec. 2011.

[4] L.-H. Wong, "A learner-centric view of mobile seamless learning," *Br. J. Educ. Technol.*, vol. 43, no. 1, pp. E19–E23, Jan. 2012.

[5] P. Candy and S. Brookfield, *Self-direction for lifelong learning: A comprehensive guide to theory and practice*. San Francisco, USA, 1991, p. 567.

[6] B. Tabuenca, S. Ternier, and M. Specht, "Supporting lifelong learners to build personal learning ecologies in daily physical spaces," *Int. J. Mob. Learn. Organ.*, vol. 7, no. 3, pp. 177–196, 2013.

[7] L. Johnson, S. Brown, M. Cummins, and V. Estrada, "The Technology Outlook for STEM+ Education 2012-2017: An NMC Horizon Report Sector Analysis.," 2012.

[8] Ericsson, "More than 50 billion connected devices," 2011.

[9] M. Specht, B. Tabuenca, and S. Ternier, "Ubiquitous learning trends in the internet of things," *Campus Virtuales*, vol. 2, no. 2, 2013.

[10] B. Dodson and M. Lam, "Micro-interactions with NFC-Enabled Mobile Phones," *Mob. Comput. Appl. Serv.*, pp. 118–136, 2012.

[11] M. Ebner and M. Maierhuber, "Near Field Communication. Which Potentials Does NFC Bring for Teaching and Learning Materials?," *Int. J. Interact. Mob. Technol.*, vol. 7, no. 4, pp. 9–14, 2013.

[3] Lifelong Learning Hub Project site. https://sites.google.com/site/lifelonglearninghubproject/

[12] T. Kuflik, O. Stock, M. Zancanaro, A. Gorfinkel, S. Jbara, S. Kats, J. Sheidin, and N. Kashtan, “A visitor’s guide in an active museum,” *J. Comput. Cult. Herit.*, vol. 3, no. 3, pp. 1–25, Mar. 2011.

[13] M. Pérez-Sanagustín, G. Ramirez-Gonzalez, D. Hernández-Leo, M. Muñoz-Organero, P. Santos, J. Blat, and C. Delgado Kloos, “Discovering the campus together: A mobile and computer-based learning experience,” *J. Netw. Comput. Appl.*, vol. 35, no. 1, pp. 176–188, Jan. 2012.

[14] S. Kubicki, S. Lepreux, and C. Kolski, “RFID-driven situation awareness on TangiSense, a table interacting with tangible objects,” *Pers. Ubiquitous Comput.*, vol. 16, no. 8, pp. 1079–1094, Aug. 2011.

[15] H. Ailisto, L. Pohjanheimo, P. Välkkynen, E. Strömmer, T. Tuomisto, and I. Korhonen, “Bridging the physical and virtual worlds by local connectivity-based physical selection,” *Pers. Ubiquitous Comput.*, vol. 10, no. 6, pp. 333–344, Mar. 2006.

[16] M. Munoz-Organero, G. Ramirez-Gonzalez, P. J. Munoz-Merino, and C. D. Kloos, “Evaluating the Effectiveness and Motivational Impact of Replacing a Human Instructor by Mobile Devices for Teaching Network Services Configuration to Telecommunication Engineering Students,” *2010 10th IEEE Int. Conf. Adv. Learn. Technol.*, pp. 284–288, Jul. 2010.

[17] G. Ramirez-Gonz’lez, C. Cordoba-Paladinez, O. Sotelo-Torres, C. Palacios, M. Munoz-Organero, and C. Delgado-Kloos, “Pervasive Learning Activities for the LMS .LRN through Android Mobile Devices with NFC Support,” *2012 IEEE 12th Int. Conf. Adv. Learn. Technol.*, pp. 672–673, Jul. 2012.

[18] D. Butler and P. Winne, “Feedback and Self-Regulated Learning A Theoretical Synthesis,” *Rev. Educ. Res.*, 1995.

[19] J. Carroll, “Five reasons for scenario-based design,” in *Proceedings of the 32nd Hawaii International Conference on System Sciences*, 1999.

[20] B. Tabuenca, M. Kalz, D. Börner, S. Ternier, and M. Specht, “Where is my time? Identifying productive time of lifelong learners for effective feedback services,” in *International Computer Assisted Assessment (CAA) Conference. Research into E-Assessment*, 2014.

[21] LAK, “1st International Conference on Learning Analytics and Knowledge,” in *International Conference on Learning Analytics and Knowledge*, 2011, p. 2011.

[22] G. Siemens and P. Long, “Penetrating the fog: Analytics in learning and education,” *Educ. Rev.*, 2011.

[23] S. Narciss, “Feedback strategies for interactive learning tasks,” *Handb. Res. Educ. Commun. Technol.*, pp. 125–144, 2007.

[24] D. Börner, J. Storm, M. Kalz, and M. Specht, “Energy Awareness. Displays Prototype for personalised energy consumption feedback,” in *In 21st Century Learning for 21st Century Skills*, 2013, pp. 471–476.

[25] D. Börner, M. Kalz, S. Ternier, and M. Specht, “Pervasive interventions to increase pro-environmental awareness, consciousness, and learning at the workplace,” *Scaling up Learn. Sustain. Impact*, 2013.

Category: Paper

Title: How to detect programming skills of students?

Authors: Štefan Pero[1]*, Tomáš Horváth[1]

Affiliations:
[1] Institute of Computer Science, Pavol Jozef Šafárik University, Košice, Slovakia

* Correspondence to: stefan.pero@student.upjs.sk

Abstract: We present a technique to detect patterns in student's program source codes. First, we describe a source code in the form of an Abstract Syntax Tree (AST). The detection of patterns is done with the SLEUTH algorithm for frequent subgraph mining on trees. We provide experiments using real data from a programming course at our university. In the paper, we discuss the relation between patterns and skills as well as some use cases and further directions of our research.

One Sentence Summary: We present a technique to detect patterns in student's program source codes.

Main Text:

1 Introduction

One of the best-known problems in educational data mining (EDM) is predicting student's performance [8]. A great deal of algorithms have been applied to predict academic success of students. However, we are interested mainly in the following issues/questions: *What lies in the background and prerequisities of students' success? What skills do students have and what is their level?* We are inspired by a real situation from the programming course at our university. Students solve programming tasks and produce source codes. Evaluation of the solutions for the tasks solved by students is a complex process driven mainly by subjective evaluation criteria of a given teacher. Each teacher is somehow biased meaning how strict she is in assessing grades to solutions. Besides the teacher's bias there are also some other factors contributing to grading, for example, teachers can make mistakes, the grading scale is too rough-grained or too fine grained, etc. Latent programming skills of students are somehow "encoded" in their source codes provided. Automatic detection of these latent skills (with or without the assistance of the teacher) remains still an open issue.

Pardos and Heffernan presented a model called "Knowledge tracing" [7] and they used it to model students' knowledge and learning over the time assuming that all students share the same initial prior knowledge. To allow per student prior information to be incorporated, they introduced an elegant way within a Bayesian networks framework that fits for individualized as well as skill specific parameters [6]. However, by considering the needed (listed) skills as attributes of the task, it is straightforward to use them also as features in prediction models [9]. Desmarais, Naceur and Beheshti [3] introduce different linear models of student skills for small, static student test data that does not contain missing values. They compare the predictive performance of their model to the traditional psychometric Item Response Theory approach, and the k-nearest-neighbors approach. In [1] they present wrapper-based method for finding the number of latent skills.

This work focuses on designing the technique to detect and recognize programming patterns from students' source program codes. Using real data, we illustrate how do patterns related to skills of students predefined by the teacher (author of the task) are discovered. The contributions of this work are the following:

- We introduce a model for representing source codes in a tree-structure.

- We propose a simple approach to detect patterns in source codes utilizing pattern mining algorithm. We illustrate the complete process of pattern detection on a real-world dataset provided us by our colleagues at our university.

2 The proposed approach

Our approach is based on pattern detection from source codes and on the analysis of the relationships between the found patterns and the skills for programming tasks pre-defined by the teacher.

2.1 Source Code Representation

Representation of source codes is a critical issue in designing the process of pattern recognition. We utilize a representation scheme of source codes in the form of Abstract Syntax Trees (AST), an example of which is illustrated in the Figure 1. AST provide detailed information about the source code which can be used for various types of analysis [4]. Various information about a source code, especially syntactic information, is represented in the form of a tree in which nodes represent entities of a source code and edges represent relations between these entities, both having their own annotations that denote also some semantic properties.

AST use a tree-like structure to represent the source code in a top-down manner. For example, Java applications are represented at the top level as applications, classes and packages while at lowest levels as methods, functions, declarations, expressions, and identifiers. Internal nodes of the AST structure represent non-terminal phrases such as statements, operations, functions and the leaf nodes represent terminal symbols, such as identifiers, and empty declarators. Edges denote tree attributes represented as mappings between AST nodes. AST nodes correspond to programming language constructs such as If-Statements, For-Statements, While-Statements, etc. as represented in the Figure 1. For more details on AST we refer to [5].

Since AST contains lots of abundant information from a pattern detection point of view, we have implemented our own filter to generate a representation of a source code in XML format from AST. The resulting representation of a source code in an XML format provides us with a better abstraction of a source code in different levels and allows us to better specify its important parts needed for the next step of our approach. For example, at the lowest level of abstraction only elements without their attributes are taken into account. With the increasing level of abstraction we consider more attributes of the elements a the source code.

Figure 1. AST structure for a *for loop* in Java and XML.

2.2 Pattern Mining

In our approach we use SLEUTH, an efficient algorithm for mining frequent, unordered, embedded subtrees in a database of labeled trees [12]. Mining frequent trees is very useful for mining semi-structured data in different domains. Several other tree mining algorithms have been proposed including TreeMiner, FreeTreeMiner, FreqT, TreeFinder, CMTreeMiner, they mine embedded/induced, ordered/unordered trees (for more details, see [13]).

Given the particular source codes, first, we represent them in relevant trees in XML format at the given level of abstraction. Consider a representation illustrated in the Figure 2, which shows an example tree of a source code represented in an XML format at the second level of abstraction where each vertex contains some additional attributes (XML element and its attributes). Second, we apply SLEUTH on the prepared dataset of trees.The aim is to find all patterns (frequent, unordered, embedded subtrees) in the input dataset. An example of such a pattern is shown in the Figure 2.

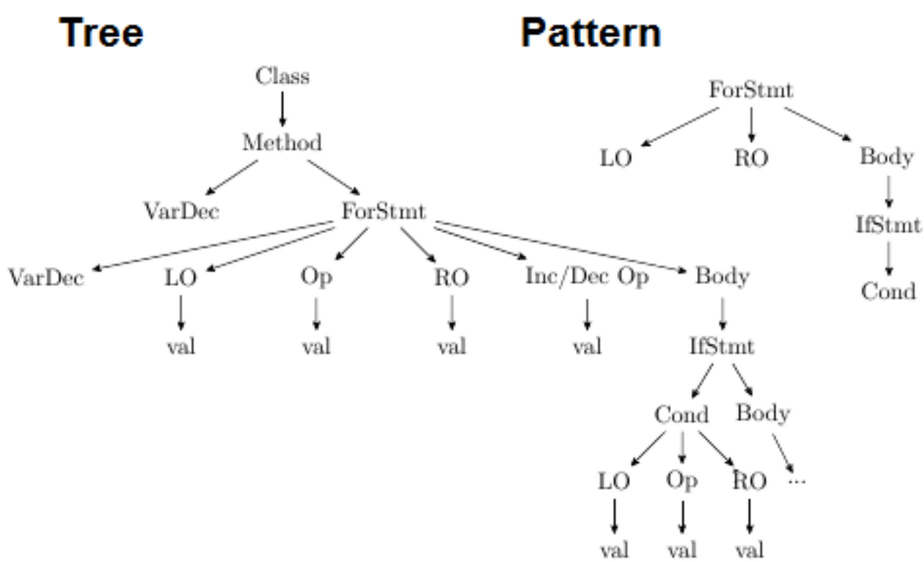


Figure 2. Example of a tree and a pattern, where *LO = LeftOperand, RO = RightOperand, Op = Operator, VarDec = VariableDeclaration, val = value.*

We are especially interested in so-called *maximal frequent patterns*, i.e. maximal frequent subtrees which are defined as those frequent subtrees none of which proper supertrees are frequent [2].

Finally, we cluster the resulting maximal frequent patterns (since many of them may be similar) and extract a set of representative patterns from each cluster of maximal frequent patterns.

2.3 Relation between Patterns and Skills

Consider the following instance of the *for loop* construction in the Java programming language.

To understand this construction of a for loop, and thus, to be able to use it during programming, we must first understand the following four programming concepts we call *prerequisites* for the for loop the model of which are illustrated in the figure 3:

- variable declaration (`int i`)
- variable assigment (`i=0`)

- relational operators (`i<5`)
- increment/decrement operators (`i++`)

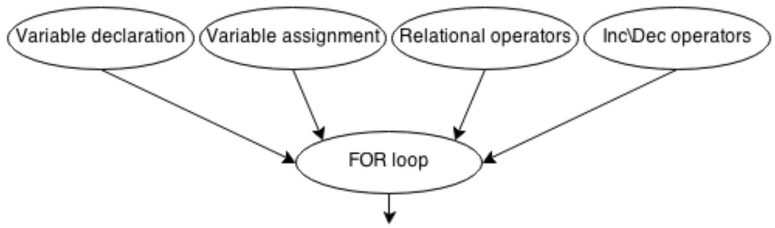


Figure 3. The model of the prerequisites of the *for loop* construction.

An important issue to mention here is "The whole is greater than the sum of its parts" principle. For example, if one knows all of these prerequisites for the for loop individually it does not necessarily mean that she is also able to construct a for loop itself.

Table 1. Skills levels.

Skill level	Examples of skills
1	variables, arrays, operators, …
2	loops, conditions, recursion, …
3	functions, procedures, …
4	complex constructions, programs, …

Since all prerequisites as well as their combinations and constructions define some kind of *skills* we can categorize the skills into several *skill levels* according to their complexity. We identified four skill levels which are introduced in the Table 1.

3 First Experiments

Experiments were performed with a real-world dataset, labeled "PAC"[1]. The dataset contains the following information about students' solutions: *studentID, taskID, teacherID, grade, review, solution (source code)*. For our experiments, however, we used only the following tuples:

$$(studentID, taskID, grade, solution). \quad (1)$$

Main characteristics of the dataset are described in the Table 2. Each task belong to one set of tasks, i.e. we consider a set of tasks as one complex task containing several subtasks.

Table 2. Characteristics of the dataset used

[1] Collected from the "Programming Algorithms Complexity" course at the Institute of Computer Science at Pavol Jozef Šafárik University during the years 2011–2014. The course consists of two parts: (A) Introduction to programming and OOP, (B) Introduction to algorithms and computations.

Dataset PAC	#Students	#Sets	#Tasks	#Codes
2011/2012 A	82	7	33	578
2011/2012 B	36	9	21	381
2012/2013 A	85	6	28	769
2012/2013 B	33	10	20	397
2013/2014 A	78	7	31	510

We realized experiments on the sets of tasks according to the described steps of our approach above, such as representation in AST, conversion to XML, pattern mining with SLEUTH and clustering the maximal patterns. When converting AST to our above defined XML format, we used the lowest level of abstraction.

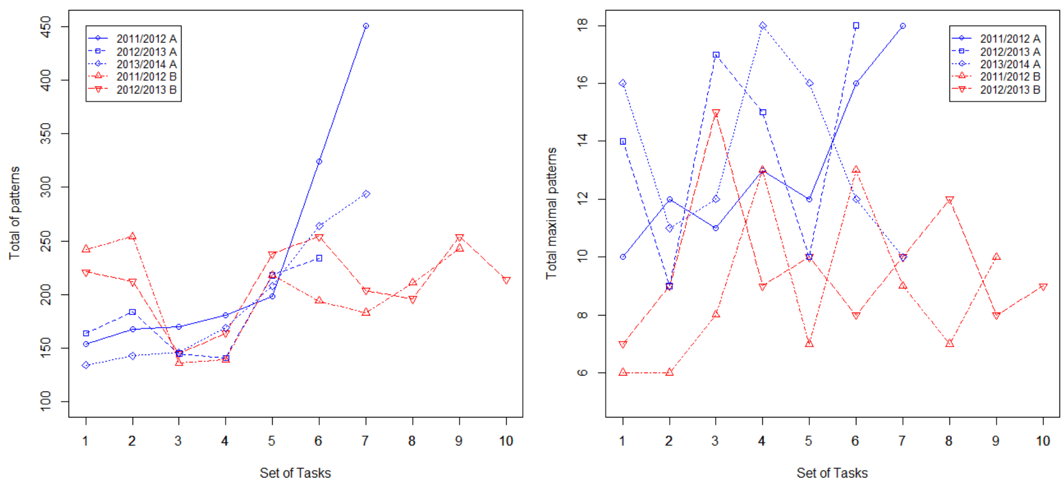


Figure 4. The number of detected patterns and maximal patterns with support=1 (i.e. 100% coverage)

The result shown in Figure 4 refer to the number of patterns and the number of maximal patterns detected in the data for different sets of tasks. Using maximal patterns we are able to filter out repetitive and meaningless patterns. In pattern mining method we used support 0.8,0.9,1 corresponding to 80%, 90% and 100% coverage, respectively.

4 Use cases and Future Work

Recommendation: In [10] we proposed a framework for an educational recommender system enriched by the role of the teacher. We call it Supervised Recommender System (SRS) which consists of three important components, the *student*, the *task* and the *teacher*, generally representing a *user*, a *item* and a *supervisor*, respectively. The idea behind SRS is that the student provides a solution (source code) according to her programming skills. The teacher verifies the fulfillment of his requirements on the the solution and provides a feedback on the student, i.e. a grading and/or a textual comment. An interpretation of such feedback could be *how student's skills meet teacher's requirements*. Using this feedback and analyzing the provided source code we could derive student's skills (patterns) and recommend those tasks to her which can more likely improve her skills. Here we have to mention, that teachers' evaluations might contain inconsistencies as we showed in our previous work [11].

Classification: By analyzing of source codes we can classify students' solutions to different classes and find frequent programming patterns discriminating right solutions from the wrong ones. Consecutively, we can use these patterns to classify unevaluated solutions to different classes. In our first experiments we used the representation of source codes at the lowest level of abstraction and frequent patterns were mined from all the solutions (source codes) not taking into account the quality/correctness of these solutions. In further work we will focus on mining patterns discriminating correct solutions from the wrong ones for what we intend to use more detailed representations of source codes at the second and third levels.

Plagiarism detection: Patterns detection might be also used for detection of plagiarism among students. The aim is to detect and point out similarities between source-code files. Naturally, these similarities should be carefully investigated by the academic to taking actions for plagiarism against the students, but the right detection of plagiarism is the first step to provide better check of codes by academic and can be used as evidence in the event that the academic decides to take matters further.

Didactics: Programming patterns and the detected skills might be very helpful for teachers to gain better insight to the programming habits of students, their main weaknesses and strengths. Patterns can uncover some common mistakes students make during programming, and thus, help to improve the didactic techniques for programming. It would be also interesting to analyze how the detected patterns in different skills levels (see the Table 1) differ from each other. For this reason we have recently started a collaboration with our colleagues working in the field of didactics of informatics which will further analyze the patterns resulting from our model.

5 Conclusions

We presented a model for mining patterns in source codes in order to map these patterns to corresponding programming skills. The proposed model consists of several phases such as source code representation in the form of AST and its transformation to XML at different levels, mining frequent maximal patterns and choose their representatives by utilizing clustering techniques. Since our work is in its beginning we provided only some early-bird experiments. We have also discussed three use cases of the mined programming patterns we would like to focus on in our future work.

Acknowledgments:

This publication is the result of the Project implementation: **University Science Park TECHNICOM for Innovation Applications Supported by Knowledge Technology**, ITMS: 26220220182, supported by the Research & Development Operational Programme funded by the ERDF and was partially supported by the research grants *VEGA 1/0475/14* and *VVGS-PF-2013-102*.

References and Notes:

[1] B. Beheshti, M. C. Desmarais, and R. Naceur. Methods to find the number of latent skills. *International Educational Data Mining Society*, 2012.

[2] Y. Chi, R. Muntz, S. Nijssen, and J. Kok. Frequent subtree mining - an overview. 2005.

[3] M. C. Desmarais, R. Naceur, and B. Beheshti. Linear models of student skills for static data. In *UMAP Workshops*, 2012.

[4] M. K. and S. Yamamoto. A case tool platform using an xml representation of java source code. *Proccedings of Fourth IEEE International Workshop on Source Code Analysis and Manipulation*, 2004.

[5] E. Mamas and K. Kontogiannis. Towards portable source code representations using xml. *Reverse Engineering, 2000. Proceedings. Seventh Working Conference on*, 2000.

[6] Z. A. Pardos, S. M. Gowda, R. S. J. D. Baker, and N. T. Heffernan. The sum is greater than the parts: Ensembling models of student knowledge in educational software. *Proceedings of ACM's Knowledge Discovery and Datamining (KDD) Explorations*, 2012.

[7] Z. A. Pardos and N. T. Heffernan. Modeling individualization in a bayesian networks implementation of knowledge tracing. *Proceedings of International Conference on User Modeling, Adaptation and Personalization, (UMAP 2010)*, 2010.

[8] C. Romero and S. Ventura. Data mining in education. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, 2012.

[9] N. Thai-Nghe, L. Drumond, T. Horváth, and L. Schmidt-Thieme. Multi-relational factorization models for predicting student performance. *ACM SIGKDD 2011 Workshop on Knowledge Discovery in Educational Data*, 2009.

[10] Š Pero. Modeling programming skills of students in an educational recommender system. *Proceedings of the 21st International Conference on User Modeling, Adaptation, and Personalization (UMAP '13)*, 2013.

[11] Š Pero and T. Horváth. Detection of inconsistencies in student evaluations. *Proceedings of the 5th International Conference on Computer Supported Education*, 2013.

[12] M. J. Zaki. Efficiently mining frequent embedded unordered trees. *Fundamenta Informaticae*, 2005.

[13] M. J. Zaki. Efficiently mining frequent trees in a forest: Algorithms and applications. *IEEE Transactions on Knowledge and Data Engineering*, 2005.

Category: Paper

Title: Helping each other teach: design and realisation of a social tutoring platform

Authors: Yiwei Cao*[1], Sten Govaerts[2], Diana Dikke[1], Nils Faltin[1], and Denis Gillet[2]

Affiliations:

[1] IMC AG, Germany, {firstname.lastname}@im-c.de

[2] EPFL, Switzerland, {firstname.lastname}@epfl.ch

Abstract: Today a wide range of technologies exist that support learning and teaching, ranging from learning management systems (LMS) to general social media platforms, such as Facebook and blogs. However, teaching with such tools and platforms can create various obstacles for teachers. Within the Go-Lab project, we aim to engage elementary and high school pupils with STEM topics by bringing online laboratory experiments into the classroom. Since using such technical software and implementing experiments into the pedagogical flow of their lessons can be hurdle for teachers, we have identified the need to support and tutor teachers on using online laboratories and their pedagogical implementation in the classroom. The Go-Lab Tutoring Platform offers teachers peer assistance for expertise sharing related to online labs, pedagogy and the Go-Lab portal. Teachers, lab owners and scientists can help each other and share their skills and knowledge. To sustain this tutoring platform, we aim to build a community of practice and apply various social media techniques. This paper elaborates on the design, the first prototype and an early evaluation of the Go-Lab social tutoring platform. Furthermore, the business model is discussed and realisable via a credit system, ranging from social rating to payment mechanisms.

One Sentence Summary: To support and educate science teachers when using new technologies such as online laboratories, a social tutoring platform is presented that provides several communication means and social reward mechanisms to foster community building.

Main Text:

1. Introduction

Nowadays an abundance of tools is available to solve numerous problems and tasks. Facing a chore, people often say: 'There is an app for that!' Likewise, also for learning and teaching various technologies are at the disposal of teachers and students, ranging from classical learning management systems (LMS), learning analytics dashboards to the repurposing of existing social media platforms, such as Twitter, Facebook, and blogs. Nevertheless, implementing these technologies in the classroom is often not straightforward and can create technical and pedagogical hurdles.

Bringing new technologies into the classroom is the mission of the Go-Lab project (http://www.go-lab-project.eu), where the main goal is to engage school students with STEM

(Science, Technology, Engineering, and Mathematics) fields by bringing exciting online laboratory experiments into the classroom. Online labs play an important role for science education at schools [9, 10, 12]. For instance, students could operate the high-powered, robotic Faulkes telescope (http://faulkes-telescope.com/) located in Hawaii from the classroom to investigate astronomy, or students can investigate particle collisions using software to analyse real data from the CERN Large Hadron Collider. However, the successful integration of such scientific software into a course can be difficult. To overcome these barriers, the Go-Lab project wants to assist and tutor STEM teachers on the use of online laboratories and appropriate pedagogical methodologies. The Go-Lab Social Tutoring Platform offers teachers assistance from lab owners, scientists and their peers who can share their expertise and experience with online labs, pedagogy and the Go-Lab portal [8]. This portal consists of two main components: the Lab Repository (http://www.golabz.eu) and the Inquiry Learning Space (ILS) Platform. The Lab Repository focuses on collecting and sharing online labs, supporting apps and inquiry learning spaces. The ILS Platform allows teachers to build such ILS [7], which are learning environments using online labs and supportive apps from the Lab Repository with learning content and tailored to the inquiry-based learning methodology. Teachers can then share such an ILS with their students.

On the Social Tutoring Platform, teachers can request help sessions with peers or experts through different communication channels. Sharing practices and user interactions are considered important factors for learning by many educators [5, 13, 6]. The Go-Lab Tutoring Platform is a social media platform to build a community of practice [13]. For instance, teachers and tutors will have social media profiles that describe their expertise and their skills. Furthermore, their skill reputation can evolve based on social ranking and commenting. Additionally, the social aspect is also reflected in a bartering process for help sessions through a credit system to reward tutors. This bartering process allows tutors to barter their knowledge and time against credits, e.g. social credits such as positive comments and badges. Teachers looking for help can become tutors after they get expertise from peer assistance. Tutors can also lose their tutor position if they get poor rating from users.

In this paper, we present the design, implementation and first evaluation of the Go-Lab Social Tutoring Platform. Our preliminary results show that a tutoring platform is highly needed for online lab communities. This paper is organised as follows. Section 2 analyses the requirements of a social tutoring system based on use scenarios. After a brief theoretical and practical overview of the state of the art, we present the conceptual design of the system, as well as a development road map in Section 4, together with a first prototype. The first evaluation results are discussed in Section 5 and we conclude with an outlook in Section 6.

2. Use scenarios and requirements analysis

The target users of the Go-Lab Tutoring Platform are mainly school teachers who potentially need help when they use an online lab in their lessons. To support sustainability of the platform, the target groups are not limited to school teacher communities. Parents can be interested in hiring tutors to help their children finish online lab school tasks. And more generally, interested people, such as hobby astronomers, can be willing to spend time and even money on using online labs for life-long learning.

To illustrate this, we present a simple scenario. A teacher, John, wants to use an online telescope lab that he found in the Go-Lab Lab Repository. But he does not know how to operate the telescope. He finds a list of lab tutors on the lab repository page of the telescope lab. He contacts one of the tutors, Chris, books a help session, connects via an online video call and gets detailed info from Chris on how to teach with the telescope. John gives a high rating to Chris and writes a positive review. Based on this, Chris' profile is awarded an "excellent tutor" badge after Chris has helped the 15th happy user.

Based on this scenario, the functional requirements of the platform include:

- *Single sign-on.* Although authentication is needed for most functionality of the Social Tutoring Platform (e.g., not for searching), it should be user friendly, thus the same login information as in the Go-Lab Portal is reused (which most social tutoring platform users will already have).
- *Managing a user profile.* A user can create and update a profile with personal information and his expertise. Tutors can add help offers and time slots (help sessions) for their specific expertise to their profiles.
- *Commenting and rating.* Users can comment and rate a tutor after they get help. This will be shown in the tutor's profile.
- *Contacting, bartering, and communicating for tutoring.* Communication channels (e.g. email and video or audio chat) are required for tutoring sessions and the bartering process between tutors and Go-Lab users. A video chatting channel with screen sharing should be provided to create a real-time, face-to-face like help session. Tutors also require a resource upload tool to share learning resources with the users who need tutoring.
- *Booking tutor time.* A booking functionality to schedule a tutoring session is also provided that gives users a clear overview of a tutor's availability via a calendar. Bookings can be cancelled.
- *Recommending tutors.* Recommendations of potential experts will be provided for the labs or ILS on the Lab Repository.
- *Searching tutors.* Users can search appropriate tutors for certain labs, ILS or specific skills.
- *Listing tutors.* A list of experienced tutors is provided per lab and ILS.
- *Assigning credits to users.* Users get a certain number of credits when they start using the Tutoring Platform in order to book a tutor's help session. This functionality extends the complete bartering process. Credits could be social media badges, vouchers, and real currency.
- *Exchange credits among Go-Lab users and tutors.* As a sequence of assigning credits to users tutors offer their help sessions in exchange for users' credits. Tutors can re-use them to get help from other tutors.

3. Related work

3.1 Communities of practice

Among many learning theories, we focus our research on the community aspects. Interactions between community members play an important role in communities. Online lab communities are groups of users who share a concern or a passion for online labs or a scientific domain and who interact regularly to educate themselves, which fits Wenger's definition of communities of practice (CoP) [13]. Furthermore, three features are specified in [13] that identify communities of practice as different from other communities:

- *mutual engagement* is the action taking place among users such as participation and collaboration, e.g. cooperative manipulation of online labs;
- *a joint enterprise* specifies a set of rules, e.g. guidelines to conduct virtual experiments;
- *a shared repertoire* refers to a common learning resource repository, e.g. online lab repositories.

Our previous research results show that social media penetrates and helps community building for teachers and research projects [2, 3]. We explore the social tutoring aspect in this paper.

3.2 Existing bartering platforms

As inspiration for the credit system, we surveyed existing bartering platforms to assess how users are motivated to help each other. Various platforms exist that barter a large range of goods or services, e.g. BarterQuest (http://www.barterquest.com/), TradeYa (http://tradeya.com/), and SwapIt (http://www.swapit.co.uk/). These bartering platforms use points or miles instead of money to equalise trades or acquire items or services. Such points can be purchased, which enables non-cash trading on these platforms. If we only observe services, knowledge and skill exchange bartering, these platforms are often evolved from helpdesks or call centres. The recently rolled-out Google Helpouts (https://helpouts.google.com) integrates the Google Hangouts video chatting functionality to offer help session with experts (e.g. in cooking or repairing your computer) for free or monetary payments.

The bartering credits range from social media badges, virtual currency, to real currency. The Mozilla OpenBadges platform (http://openbadges.org/) develops the Open Badges standard for online assessment. Similar to badges in FourSquare (http://foursquare.com/), learners are motivated to learn by collecting widely accepted Open Badges as an incentive method. Social help platforms, such as the Q&A site StackExchange (http://stackexchange.com/), use social rating mechanisms to rate the best answer and rate the users who provide the answers. [11] proposed a competence model with a virtual currency based decentralised credit system to make incentives for self-regulated learner communities. Google Helpouts employ Google Wallet for the payment system with real currency. In the context of teachers' communities, quality labels at national and European levels are assigned to motivate teachers in eTwinning (http://www.etwinning.net/).

In comparison, currency-based exchanges bring users monetary profits, while social media badges motivate users through gamification approaches. Such ratings are then used to compute an overall trust score of the expertise of a tutor, which often provides extra motivation for these tutors [4].

4. System architecture and implementation

The Go-Lab Tutoring Platform enables users to get experts' help and those users can eventually become online lab experts. The Go-Lab Tutoring Platform supports the online lab knowledge and skill acquisition process of the users. The concept of communities of practice supports this dynamic process. The lab repository collects online labs and inquiry learning spaces. A list of recommended lab tutors is listed on each lab page of the lab repository. Tutors and teachers carry out mutual engagement via creating help sessions, searching for tutors, getting recommended tutors, conducting help sessions, and ranking or commenting. The award mechanism of assigning social media badges or involving payment is settled to maintain the platform as a joint enterprise. Hence, the social tutoring platform is capable of delivering community specific tutoring services. At the same time, the Go-Lab Tutoring Platform can benefit of the dynamics of a social network, for instance regular users that are highly rated can be upgraded to tutors based on this community (cf. [1]).

4.1 Architecture of the Go-Lab Tutoring Platform

Figure 1 depicts the architecture of the Go-Lab Tutoring Platform and its relationship to the Go-Lab portal and booking system. The Go-Lab Tutoring Platform is supported by a credit system and a set of components to find and book tutors. The social platform components manage user and tutor profiles and provide social features such as user comments and ratings on the user profiles and the help sessions. A user profile includes the name, contact information, a short description, and expertise in related online labs and inquiry spaces, and an activity log. Users can write comments related to the help session and rate the help sessions and the tutor using a five star rating on each other's profile. The average rating is calculated and listed in each user profile. The contact and communication component provides different contact channels between users and tutors. Such channels are required to contact, to barter for a help session, and to conduct the help session. They comprise emails, contact forms, chat rooms, screen-sharing, and video-chatting. For example, one can email a tutor to make an appointment of a help session, while the help session itself is done through the video chatting tool.

Figure 1. System architecture

In addition, users can book a help session with a tutor via the tutor booking component, which supports calendar-based booking through the Go-Lab booking system. The booking itself consists of different checks. First, it is checked whether the teacher has sufficient credits to pay for this help session. If this is not the case, then the transaction aborts. If there are sufficient credits, the availability of the tutor is validated by the tutor booking component using the booking system logic via the Tutor Booker component interface. If the tutor is in the meantime unavailable, the transaction is aborted. Only when the tutor is available and there are sufficient credits, the credits are transferred from the teacher to the tutor profile using the credit system. In case an error occurs with this payment, the teacher is notified. Otherwise, the tutor booking is created.

Furthermore, one can search for tutors via the tutor search component and get recommendations of tutors on the portal through the tutor recommender component and the tutor search interface. The credit system provides mechanisms to award tutors for the provided help.

Besides the social reputation growth of users on the platform (e.g. via gamification badges or scoring systems), the credit system attempts to explore potential business models for experts and users in need of help. It uses both vouchers and monetary bartering. Go-Lab teacher communities can get vouchers for free supported by the Go-Lab project, while other users need buy vouchers. Thus, through monetary payment hobby online lab users can get access to a variety of remote labs and virtual experiments, which also provides an exploitation plan for sustainability of Go-Lab portal.

The Go-Lab Tutoring Platform provides on the one hand assistance to teachers that need support to operate online labs and inquiry learning spaces; and on the other hand a social platform for tutors and experts to improve the visibility of their expertise. The tutor's social profile together with the credit system to award tutors, will enable this visibility. Bartering and currency-free bartering will be used to award tutors for the provided help. This bartering process is supported by social rating based social media badges. Such social media badges indicate the expertise or trust score of a tutor. To make this work, a credit system or point system is needed to conduct the bartering process. The credit system is initially optional for the Go-Lab Tutoring Platform to ensure teachers to receive tutors' support for free. Gradually, the system applies vouchers in the credit system. We plan to involve lifelong learners gradually through payment, which can sustain the Tutoring Platform beyond the Go-Lab project's funding.

4.2 User interface

The Go-Lab Tutoring Platform user interface offers its users to search tutors, to view tutors' profiles, to contact tutors and book help sessions. Most important, it enables users to carry out the help session. It also provides a tutor list on the Go-Lab Portal. When one views the online labs and ILS on the lab repository, one can also see the tutor list with their ratings.

Each tutor's profile is managed on the platform as depicted in Figure 2. It displays a basic description of a tutor with contact information and average ratings as well as labs and inquiry spaces in which the tutor has expertise. A tutor can list the help sessions she/he offers, which can be booked. Tutors have access to a centralised booking calendar, called 'My calendar', by clicking the booking button in the upper right corner, which employs the calendar manager of the booking system. Users can comment and rate this tutor. A user's rating will be calculated as an average. More advanced, robust rating metrics can be considered when needed. A first prototype has been implemented and is available at http://dev.bpf.golabz.eu/.

Figure 2. Tutor profile management and the list of help session offers.

5. Evaluation

In order to continuously improve the design and user experience of the Tutoring Platform, participatory design surveys are conducted to evaluate the current prototype and assess whether the user requirement assumptions are correct. The first survey focused on users' skills and knowledge about physical and online labs, their need for experts' help, the appropriate incentives for tutors, and their experience with the Go-Lab Tutoring Platform prototype.

Seven survey participants were introduced to the platform and played the role of either a tutor or a teacher. Each created a profile. After that, test tutors created help offers. Test teachers explored the tutors' profiles and searched for help sessions. Afterwards, test teachers booked help sessions. If a help session was booked successfully, a Google Hangout link was created for this help session. Then, tutors were helping teachers via Google Hangout. After the hands-on experience, seven participants completed the online survey.

The survey results from the first participatory design workshop show: (i) the users need help and support because they face problems and look for expertise during online lab use; (ii) incentives such as being paid or getting social badges motivate tutors mostly. Figure 3 depicts the results related to which incentives users prefer in exchange for tutoring (using Likert scales from '1 – absolutely inappropriate' to '5 – absolutely appropriate'). On the one hand, the participants are indecisive whether they want to provide help for free (Figure 3a) with an average rating of 3.2. On the other hand, they prefer to tutor in return for social media badges (3c, average rating 4.3) or want get paid (3b, average rating 3.9). Bartering for getting help from other tutors (3d, average rating 3.9) is also perceived as positive. Overall, the proposed incentives are perceived as appropriate. Furthermore, participants were asked which type of help they would prefer. The two most valued types of help were face-to-face and online meetings. Still positively perceived were a helpdesk and online discussion fora, while the participants were indecisive on social media and online search.

Figure 3. User survey on incentives in the Go-Lab Tutoring Platform

Further feedback refers to the user account integration with one's Google account and limitations of applying only Google Hangout. A search mechanism for domain-specific help sessions is deemed important. These comments will be taken into consideration for the next iteration of the prototype.

6. Conclusion

A social tutoring platform is a complex system that requires much more functionality than just some social features. We have applied the communities of practice theory to support a community of online lab experts acting as tutors and teachers. Our Go-Lab Tutoring Platform has the potential to make the Go-Lab Portal comprise a sustainable market place of knowledge and skills about online labs and their pedagogical implementation. We have proposed several communication channels to provide assistance and a credit system providing different mechanisms (e.g. social badges) to award tutors for their time and their expertise. Furthermore, a first version of this platform has been implemented and evaluated. It is a promising solution to support teachers' lab usage skills by tutoring and knowledge sharing. Furthermore, the Go-Lab Tutoring Platform fosters the evolution of specific user communities who have or search for expertise, in order to operate online labs or creating ILS properly.

One can see the Go-Lab Tutoring Platform as a support mechanism for the Go-Lab Portal and its Lab Repository. By providing tutoring activities more teachers will be attracted and supported to use more online labs and the portal. The credit system with vouchers, social badges and payment with real currency could reach out to external user communities beyond teachers and students. Through their monetary support the online labs and the Go-Lab portal can be made sustainable beyond the Go-Lab project's lifetime.

Our first evaluation shows that online lab users do need help and value skill bartering via a credit system to motivate users to help each other. The prototype still needs further improvement and a larger user evaluation needs to be conducted to assess its usability and business model, which assures the realisation of the credit system. The current prototype has just demonstrated the basic features of a social tutoring platform. Hence, we plan to extend it with further features and functionality in the future, such as tutor recommendations and advanced search.

Acknowledgments: This research work is partially funded by the European Union in the context of the Go-Lab project (Grant Agreement no. 317601) under the Information and Communication Technologies (ICT) theme of the 7th Framework Programme for R&D (FP7). This document does not represent the opinion of the European Union, and the European Union is not responsible for any use that might be made of its content. We would like to thank Faysal Cherradi (IMC AG) for his support with the technical implementation.

References and Notes:

1. Cao, Y., Hannemann, A., Klamma, R., Kovachev, D., Renzel, D.: Mobile multi- media management for community-aware storytelling. In: Hara, T., Jensen, C.S., Kumar, V., Madria, S., Zeinalipour-Yazti, D. (eds.) Mobile Data Management. pp. 59–64. IEEE Computer Society (2010).

2. Cao, Y., Hannemann, A., Klamma, R., Renzel, D.: A community success model for gaming communities. Journal of Multimedia 4(2), 87–93 (April 2009).

3. Cao, Y., Klamma, R., Jarke, M.: Mobile multimedia management for Virtual Campfire - the german excellence research cluster UMIC. International Journal on Computer Systems, Science and Engineering (IJCSSE) 25(3), 251–265 (May 2010).

4. Chang, H.H., Chuang, S.S.: Social capital and individual motivations on knowledge sharing: Participant involvement as a moderator. Information and Management 48(1), 9–18 (Jan 2011).

5. Dewey, J.: Experience and education. The Kappa Delta Pi lecture series, Simon & Schuster (1997), http://books.google.de/books?id=UWbuAAAAMAAJ

6. Garrison, D.R., Arbaugh, J.: Researching the community of inquiry frame- work: Review, issues, and future directions. The Internet and Higher Education 10(3), 157–172 (2007), http://www.sciencedirect.com/science/article/pii/S1096751607000358

7. Gillet, D., de Jong, T., Sotiriou, S., Salzmann, C.: Personalised Learning Spaces and Federated Online Labs for STEM Education at School: Supporting Teacher Communities and Inquiry Learning. In: Proceedings of the 4th IEEE Global Engineering Education Conference (EDUCON). pp. 769–773. IEEE (2013).

8. Govaerts, S., Cao, Y.C., Vozniuk, A.V., Holzer, A., Garbi Zutin, D., San Cristobal Ruiz, E., Bollen, L., Manske, S., Faltin, N., Salzman, C., Tsourlidaki, E., Gilet, D.: Towards an online lab portal for inquiry-based stem learning at school. In: Proceedings of the 12th International Conference on Web-based Learning. ICWL '13, Springer Verlag (2013).

9. de Jong, T., Linn, M.C., Zacharia, Z.C.: Physical and virtual laboratories in science and engineering education: review. Science 340(6130), 305 – 308 (2013), http://doc.utwente.nl/87051/

10. de Jong, T., Sotiriou, S., Gillet, D.: Innovations in STEM education: The go-lab federation of online labs. Smart Learning Environments (2014), (to appear).

11. Limpens, F., Gillet, D.: A competence bartering platform for learners. In: Leung, H., Popescu, E., Cao, Y., Lau, R.W.H., Nejdl, W. (eds.) ICWL. Lecture Notes in Computer Science, vol. 7048, pp. 148–153. Springer (2011).

12. Orduna, P. et al.: Generic Integration of Remote Laboratories in Public Learning Tools: Organizational and Technical Challenges. In: The 44th Annual Frontiers in Education Conference (FIE 2014), (to appear).

13. Wenger, E.: Communities of practice - Learning, meaning, and identity. Cambridge University Press (1998), http://www.ewenger.com/theory/index.htm

Supplementary Materials:

Figure 1. System architecture

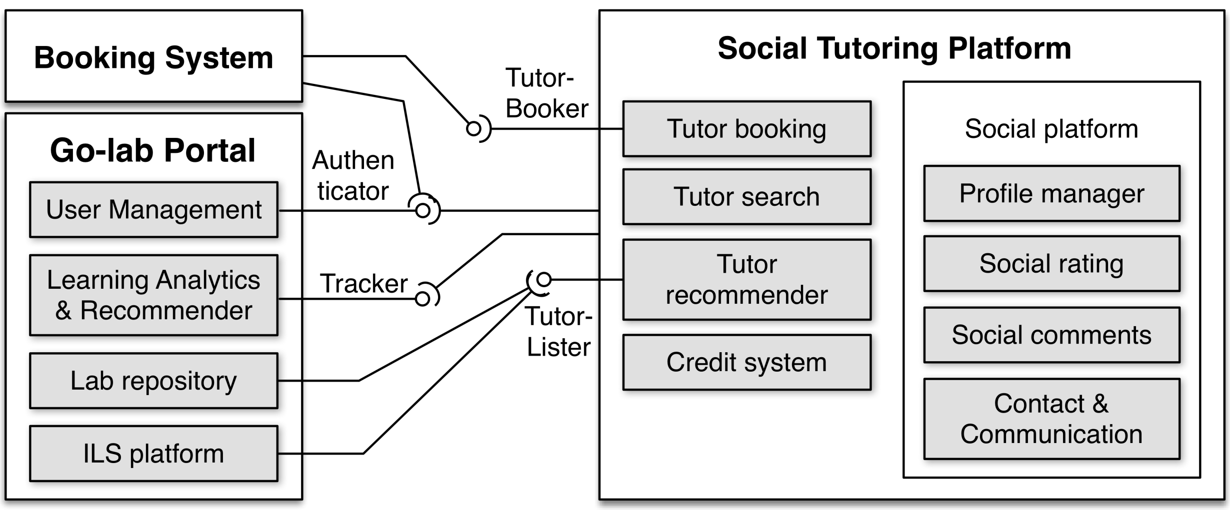


Figure 2. Tutor profile management and display of help session offers

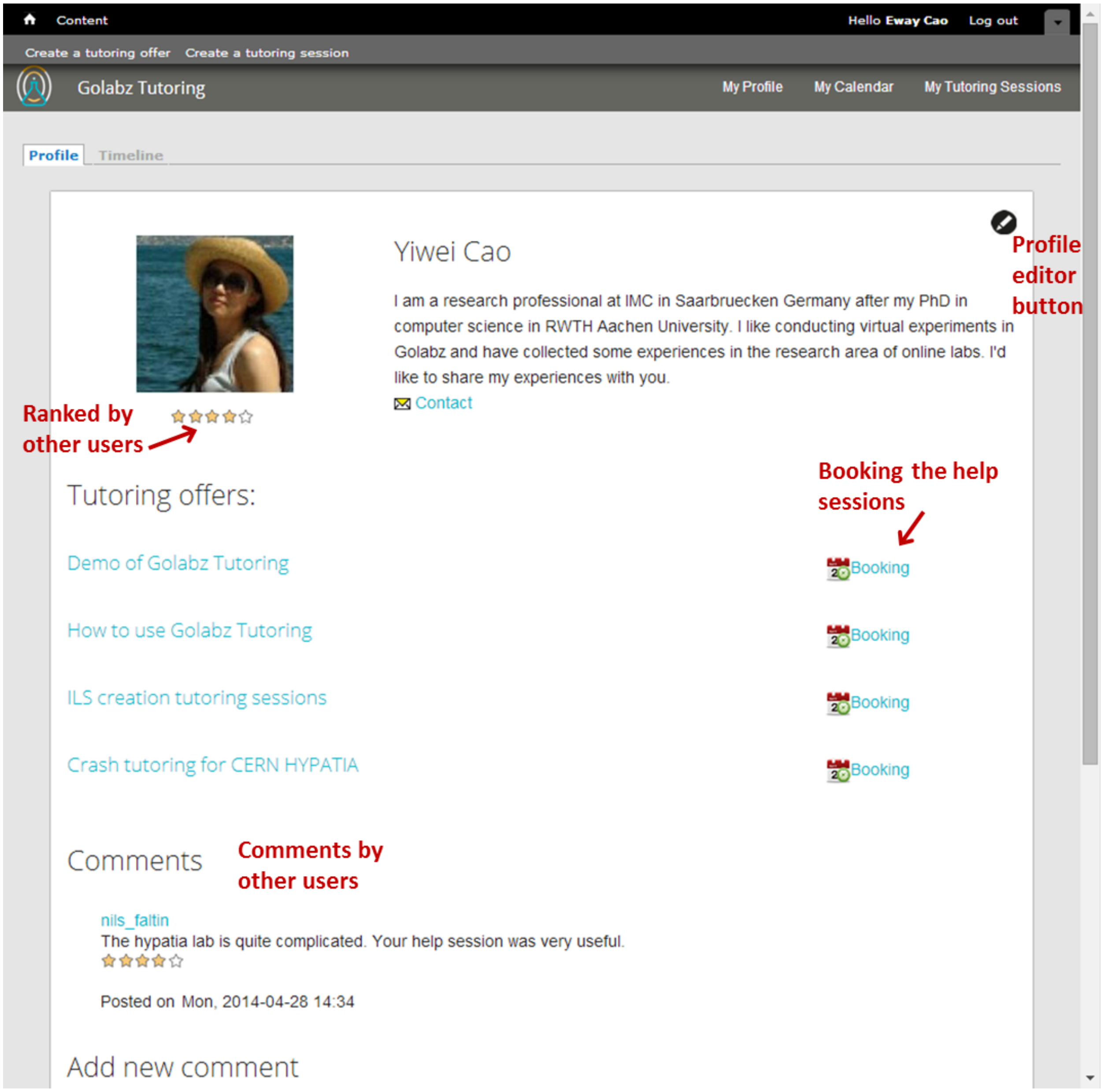


Figure 3. User survey on incentives in the Go-Lab Tutoring Platform

Category: Paper

Title: Enhancing Assisted Learning with 3D Virtual Environments

Authors: Erezi R. Ogbo[1], Alan Miller[1], Lisa Dow[1], Colin Allison[1]

Affiliations: [1]University of St Andrews

Abstract: 3D virtual environments (3DVE), also referred to as virtual worlds or the immersive web, are networked multi-user client-server software systems designed so that the natural human perception of the world is represented using 3D objects. Avatars represent users, allowing them to interact with other avatars, non-player characters and objects within the environment. 3DVE are used in gaming, reconstructions, business and education. This study investigates 3DVE as a tool for *assisted learning*. A prototype of a 3DVE for assisted learning was developed to provide learners with disabilities educational resources supporting life skills. The research was carried out in a secondary school in Scotland where participants were learners within the Department of Assisted Support. The case study focuses on learning about safety in the kitchen and carrying out basic everyday tasks. This paper discusses different learning scenarios, the physical and virtual environment and the usability of a 3DVE for learners with special educational needs. The results demonstrate that 3D virtual environments can be used to enhance the learning process in four main areas: social interaction, collaborative working, self-directed learning and exploration.

One Sentence Summary: Reconstructed 3D models afford familiarisation and reinforcement in life skills, enhancing the learning experience of assisted support learners.

Main Text:

Introduction: Learning Disabilities

Reading, writing, mathematical calculations and basic life skills are considered essential for independent living in modern society. Their importance is reflected in the curriculum of education systems which teach these skills to learners as core subjects throughout formal schooling. Whilst many learners achieve the benchmark for these skills, those that do not have attracted the interest of educationalists, medical professionals and psychologists. Within the section of learners yet to attain the expected skills level, there exists a sub-section of 'unexpected underachievers' identified as having "learning disabilities". Learning disability as a field of research is rooted in the premise that the cause of learning difficulties is a dysfunction in the neurobiological system of an individual. The United States National Joint Committee on Learning Disabilities [1] defined learning disabilities as a general term that refers to a heterogeneous group of disorders manifested by significant difficulties in a number of learning domains such as reading, speaking and listening [2].

This group experience lower learning ability and learning progression rate when compared to other children of the same age with similar learning and social opportunities and can display poor memory retention, whilst others have lower learning abilities due to one or more of: retarded motor skills, poor writing skills, reduced ability to read text, inability to spell correctly, lack of text organization skills and poor comprehension [3]. Learners with Autism Spectrum Disorder (ASD) or Down's syndrome experience challenges when coping with everyday activities and social interactions. Autistic children are often characterized with low memory and little imagination. This makes certain objects and places potentially harmful. The Scottish Curriculum for Excellence aims to produce confident individuals that are capable of learning and applying new skills, and succeeding as a responsible member of society. To prepare learners for successful independent lifestyles, one of the subjects undertaken is Life Skills. This subject teaches learners how to cook simple dishes and how to use everyday objects safely in a kitchen setting. However, when experiencing a real kitchen setting, educators have witnessed this type of learner injuring themselves while attempting to carry out activities in the kitchen and learning about safety: "One of the learners keeps cutting his fingers with a knife whilst in the kitchen because he always picks up the wrong end of the knife" as described by a teacher in the Department of Assisted Support.

3D Virtual Environments

3D software systems are heavily utilised by modern computer games and have more recently been explored for use in reconstruction of ancient sites [5], in businesses building virtual communities [6] and education [7]. 3D virtual environments (3DVE), also referred to as *virtual worlds*, are networked immersive multi-user client-server software systems designed so that the natural human perception of the world is represented using 3D objects. Avatars represent users, allowing them to interact with other avatars, non-player characters and objects within the environment [8], [9]. The ability of users to freely construct and manipulate objects in this environment without the limitations of physics or a 2-dimensional view is one of the strong factors supporting their use in education.

The learning affordances of 3D virtual environments make them a potentially powerful educational tool. Studies suggest that autistic persons have social desires but often display unacceptable social behaviours due to their inability to initiate conversations or understand non-verbal social communications [10]. In 2012, Schmidt et al [11] carried out a study using a 3D environment to assist young people with ASD and showed that the focus group responded and continued interactions with each other within the environment. Children with ASD experience presence and spatial awareness in 3DVEs in a manner similar to children without learning disabilities however their social judgements in-world remained the same as they displayed in their traditional classroom environment [12].

Supporting the Learning Process

The majority of the learning population can easily acquire and apply crucial learning skills. These skills are not only necessary within a formal learning environment, but can also be applied to safety in everyday living tasks. For learners with special needs, these skills are difficult to learn and they can be at risk of self-harm in everyday environments such as the kitchen. Also, due to lack of confidence, social interaction is often quite low amongst this group. In a traditional setting, the teacher is responsible for teaching the learners both theoretically and practically on safety in the home and basic human social cues.

Using avatars to represent a user within the 3DVE allows the user to experience realistic simulations of the real world. 3D environments provide a 'safe' place to practice potentially dangerous tasks such as using a knife to cut food. In addition, it allows learners to participate in collaborative working and social interaction through in-world chat functions without being self-conscious.

3DVE also allow the user to simulate and push the boundaries of human navigation using walking, running and flying modes. Learners with special educational needs face challenges with coordination, operating gadgets and spatial coordination. Our initial research investigated the ability of learners to navigate within the 3D environment and recognise objects. In achieving this, we were able to observe the navigation modes used to explore the environment and the type of items successfully identified by learners.

Scope of Work

Three studies were carried out at a secondary school (ages 12 – 17) over a period of twelve weeks. Forty learners between S1 and S6 at a secondary school in Scotland, UK participated in the study. The learners had been diagnosed with a wide range of learning difficulties including Down's syndrome, Dyslexia, Dysgraphia, Autism and Dyscalculia. An initial observation was conducted with learners in their traditional learning activities and environments, the goal being to understand the techniques used and the challenges faced by the learners. Following on from this, two further studies were carried out introducing the students to a specially created 3D virtual environment. In both studies, key areas of interest were: i) the ability of learners to recognise objects in the environment; ii) the effect avatars had on the learning process; iii) how distracted or engaged the students were when using the resource; and iv) features of the environment that the students found most interesting. The software engineering development process is shown in Figure 1.

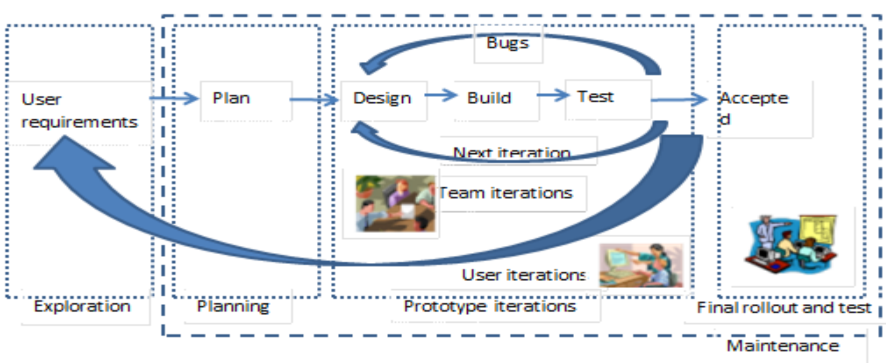


Fig. 1. An overview of the virtual kitchen development process used to carry out the study on learning about safety in the kitchen. A user-centred approach was applied and the user requirements were verified and improved through an iterative development process.

Developing a 3D Kitchen

The virtual environment used in this study was created using OpenSim. Pictures of the actual kitchen were taken and then used to reconstruct a 3D model of the kitchen. See Figure 2.

Fig. 2. The actual kitchen used by the School to teach Life Skills and safety in the kitchen and the corresponding 3D model used in the final study

One challenge faced during the reconstruction was scaling. The actual kitchen is small and compact; therefore 1:1 scaling would result in difficulties when navigating the avatar. The building plan was unavailable therefore estimates based on the avatar were made in determining the size and layout of the building. OpenSim has limitations in the level of detail afforded to an object. Creating objects is time-consuming and the build interface is not always intuitive. Large objects with simple structures (the building and cupboards) were built in OpenSim. Other objects (e.g. microwave) were created using Google SketchUp Open-source objects were also imported from Google 3D Warehouse.

The objects and associated tasks forming part of the study were designed to cover the life skills commonly identified as lacking in children with special needs. The virtual kitchen was augmented by 2D webpages which provided the group with a range of interactions and feedback to suit their learning needs and the type of learning task being carried out. The 3D technology was selected to give the learners knowledge of the spatial representation of the kitchen area and items in the kitchen. Interactions with items in the kitchen were linked to the supporting webpages which included quizzes (see Fig. 3).

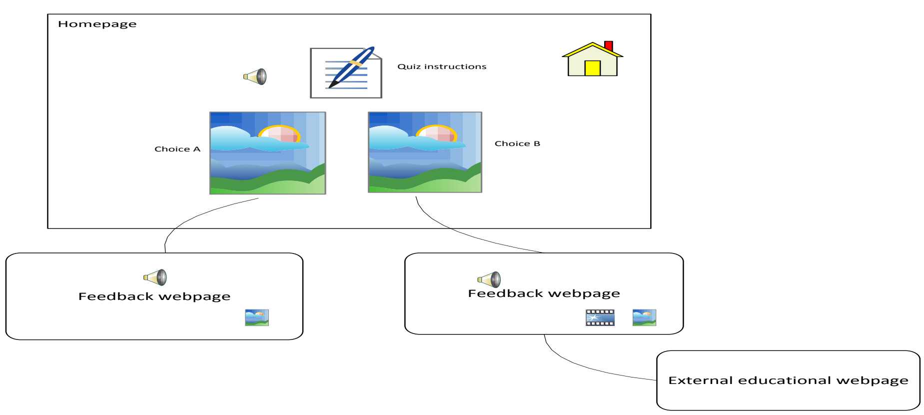


Fig. 3. The homepage of the web quiz has a written question at the top and two pictures for the students to select their answer from. Clicking on a picture opens a feedback page using audio and picture feedback.

Accessing the 3D Kitchen

The avatar in the environment can be controlled using different devices. The default set up with the environment was a Microsoft Xbox controller. This was selected as the default device in order to enhance the game-like experience of interacting with the environment. Also, studies have shown that the motor skills of children with learning difficulties do not impede their ability to use game controllers [13], [14], [15], [16], [17]. However, for users that have difficulties using the Xbox controller – perhaps due to lack of experience – the options of keyboard and mouse was available. OpenSim runs on a PC. It can be accessed from a networked server or from a local host server on a local computer. The environment was projected using an electronic board, a smart TV, laptop and desktop systems, which were all connected to the same LAN, an intranet. This allowed the different users logged onto the environment to view and interact with each other.

Observing the Learning Scenarios

The participants in this study face challenges with communication therefore observational methods were deemed most appropriate and comprised the primary data collection method. However a small questionnaire was used to collect data from the learners, and teachers were interviewed after the study. Learners were also encouraged to provide open-ended feedback using drawings and short reflective accounts about their experience using the environment. From the data collected, the learners expressed their opinions relating to virtual and traditional environment, the usability of the controllers, if they enjoyed the experience and aspects that could be improved.

An accurate quantitative analysis of the study proved difficult. Notes were transcribed from the observational studies. Based on these transcripts, and data collected through the questionnaires, reflective accounts and drawings, inferences were drawn. Feedback from teachers was collected and transcribed relating to the impact the environment had on the learners and areas, and improvements that could be made from their perspective.

Learning Scenario 1 – Traditional Environment

An initial study was carried out to gain a better understanding of the curriculum, needs of the learners and the teaching methods used. During classroom activities learners were asked to complete tasks based on their level on the ability continuum. The tasks completed included (1) making a sandwich (2) reading comprehension (3) cutting a piece of wood. Learners displayed difficulties with memory retention, motor skills, coordination, reading and writing. In this environment, the teacher plays a central role in the learning process. Teaching was reinforced using pictures, speech, signs and symbols using the Boardmaker tool. The methods in use and difficulties observed during this initial study prompted areas to observe more closely in scenario 2 and informed design aspects of the 3D kitchen, used in the final study.

Learning Scenario 2 – Spatial Awareness and Navigation

The second study investigated the ease with which learners with special educational needs could navigate within the virtual environment, their spatial awareness, level of engagement with the environment and their ability to carry out exploratory learning activities. Success and difficulties in completing tasks and interacting with In-world objects informed the design of the 3D kitchen.

Learning Scenario 3 – Safety in the Kitchen

The final study focused on using 3DVEs for teaching safety in the kitchen. A 3D reconstruction of the existing school kitchen was developed and used. The aim of this study was to explore different learning affordances supported by the environment and its ease-of-use for the target users. Familiarisation with the 3D kitchen and its objects could be used to prepare learners for a subsequent visit to the School's kitchen, or alternatively reinforce life skills after visiting the location. Learners were encouraged to explore the kitchen and interact with objects. Interacting with specific objects presented notecards (with minimal text), caused the objects to react (opening doors), opened external webpages or played in-built audio and video media.

Results and Interpretation

Learners exhibited a high level of self-paced learning. Without being prompted, they explored the buttons on the Xbox controller to find out how it controlled the avatar. However, some participants had difficulty using the controller. Learner A, who has been diagnosed with autism and has a history of problems adjusting to a new environment, was keen to use the virtual environment. Learner B complained about the controllers and said they were not familiar with using them because they did not have an Xbox at home. By the next session, there was considerable improvement in their use and confidence with the controllers. Learner C had difficulty with navigation during the first session but by the end of the session had improved considerably.

All participants experienced difficulty navigating through buildings, therefore an instructor had to take control of an avatar in the environment and 'lead' them through the buildings. Another issue with self-directed exploratory learning within this environment is the possibility of the learners being interested in activities other than the intended tasks. As the environment is inherently gaming, combined with the use of Xbox controllers and the lack of strict learning outcomes, the learners often focused their attention on exploring the navigation options of the avatar; flying, walking and running. Clicking on objects also invited the learners to take a web-based quiz. This quiz was displayed using pictorial choices, Boardmaker symbols, audio and minimal text. Interaction options included rollover techniques by placing the cursor over a picture or clicking on the picture. Learners were able to recognise that the kitchen was modelled on the School's kitchen.

Cooperation and collaboration are important skills reinforced by teachers throughout the Life skills activities. To continue this theme learners were placed in groups of 5 and provided with a single controller. Three groups took part in the study at a time and were provided with tasks to complete working as a group. Working together produced little difficulty however some participants were reluctant to handover the controller. This provided an opportunity for the learners, when prompted to develop mediation and negotiation skills.

Avatars represent users in 3D environments this removes scrutiny away from the actual learner encouraging them to attempt interactions they would have otherwise avoided. Higher levels of social interaction were observed when compared to the traditional classroom environment. Due to the close proximity of the users in the same room, the speech functionality supported by the environment was not utilised. Using their avatars, communication was achieved using the in-world chat feature allowing dyslexic learners to further develop reading and writing skills. Autistic learners showed considerable improvement through interacting with other learners and their willingness to try out a new environment. This could be attributed to the removal of not being required to understand the non-verbal cues that are distinctly human.

There was competition for the controllers, but learners passed them to each other and helped identify objects and locations while someone else controlled the in-world avatar. Through chat IM on OpenSim, the learners interacted with each other and eagerly incorporated challenge and competition into the learning activities.

Feedback from Learners and Teachers

In each study, learners were asked informally for their thoughts about the environments and were given questionnaires to fill. The following are quotes from the learners; "Searching for information on virtual environment was more interesting than searching on Google", "I like it", "brilliant", "cool", "historic", "peaceful". Learners also said they felt like they were actually at the reconstruction site while using the environment. After the second user session, a few learners drew pictures and compiled a short reflective account on their experience. When using the virtual kitchen in the final study, they were able to recognise it as a model of the kitchen used at their school. Some experienced difficulty in identifying what to interact with. With prompts from the development team, they were able to initiate and complete learning activities.

Teachers acknowledged that the level of detail in the environment was suitable for the needs of the lowest ability group. The use of labels for objects in the kitchen was deemed very helpful. The picture labels on cupboards and drawers are suitable for autistic learners providing visual clues as to what is behind the door. The audio functionality is very suitable for some of the learners with reading difficulties. Teachers also noted that Learner A had never been seen to accept a strange process or procedure so quickly before. Teachers were confident that the environment would be useful to the department especially if developed further with increased functionality.

Conclusions

This study explored the use of virtual worlds in teaching life skills to students with learning disabilities. It has been shown that 3D virtual environments can be crafted to provide engaging scenarios, which can enhance the learning experience for learners with a wide range of learning difficulties. In order to develop a successful virtual learning environment, key functionalities to consider are the interactions and activities available to users. This study made use of text, animations, videos, pictures, audio, and online quizzes all of which provide immediate feedback.

Good preparation is essential. Before deployment, teachers should be familiar with the environment and have full control over their avatars and be able to communicate with learners through the in-world chat or speech functionality. Learners are likely to have a better understanding of an environment that they are already familiar with, therefore using learning content that reinforces their traditional environments or using tutorial videos featuring their teachers is recommended.

Feedback provided by learners and teachers, highlight the potential of 3D environments for use in the area of assisted learning. This research demonstrates that across the continuum of learning and social difficulties, assisted learners are able to use Xbox controllers in accessing virtual environments and displayed the ability to carry out self-paced learning activities. An empirical study to investigate the effects over an extended period of time could provide further evidence. The prototype allowed exploration of different learning interactions and methods for feedback. The use of animated feedback within the world to improve the user experience could be explored. An investigation into the learning affordances of the virtual environment to determine the factors, which provide a more suitable learning experience for the different learning difficulties, would also be beneficial.

References and Notes:

1. NJCLD, "Learning Disabilities: Issues on Definition (1990)," 1990. [Online]. Available: http://www.ldonline.org/about/partners/njcld. [Accessed: 06-Jun-2013].
2. G. R. Lyon, J. M. Fletcher, S. E. Shaywitz, B. A. Shaywitz, J. K. Torgesen, F. B. Wood, A. Schulte, and R. Olson, "Rethinking Learning Disabilities," Rethinking Special Education for a New Century, pp. 259–287, 2001.
3. O. E. Hetzroni and B. Shrieber, "Word processing as an assistive technology tool for enhancing academic outcomes of students with writing disabilities in the general classroom.," Journal of learning disabilities, vol. 37, no. 2, pp. 143–54, 2004.
4. National Universities Commission, "NUC, ACSI Organise Sensitisation Seminar on Autism," 2014.
5. [S. Kennedy, L. Dow, I. Oliver, A. Sweetman, Rebecca Miller, A. Campbell, C. Davies, J. McCaffery, C. Allison, D. Green, J. Luxford, and R. Fawcett, "Living History with Open Virtual Worlds: Reconstructing St Andrews Cathedral as a Stage for Historic Narrative," in Proceedings of the 2nd European Immersive Education Summit, 2012, pp. 146–160.
6. L. Chittaro and R. Ranon, "Adaptive 3D web sites," pp. 433–462, Jan. 2007.
7. I. Duncan, A. Miller, and S. Jiang, "A taxonomy of virtual worlds usage in education," British Journal of Educational Technology, vol. 43, no. 6, pp. 949–964, Nov. 2012.
8. A. Berns, A. Gonzalez-Pardo, and D. Camacho, "Game-like language learning in 3-D virtual environments," Computers & Education, vol. 60, no. 1, pp. 210–220, Jan. 2013.
9. B. Dalgarno and M. J. W. Lee, "What are the learning affordances of 3-D virtual environments?," British Journal of Educational Technology, vol. 41, no. 1, pp. 10–32, Jan. 2010.
10. B. S. Myles and R. L. Simpson, "Asperger Syndrome: An Overview of Characteristics," Focus on Autism and Other Developmental Disabilities, vol. 17, no. 3, pp. 132–137, Jan. 2002.
11. M. Schmidt, J. M. Laffey, C. T. Schmidt, X. Wang, and J. Stichter, "Developing methods for understanding social behavior in a 3D virtual learning environment," Computers in Human Behavior, vol. 28, no. 2, pp. 405–413, Mar. 2012.
12. S. Wallace, S. Parsons, A. Westbury, K. White, K. White, and A. Bailey, "Sense of presence and atypical social judgments in immersive virtual environments. Responses of adolescents

with Autism Spectrum Disorders.," Autism : the international journal of research and practice, vol. 14, no. 3, pp. 199–213, May 2010.

13. E. Pearson and C. Bailey, "Evaluating the potential of the Nintendo Wii to support disabled students in education," ICT: Providing choices for learners and …, pp. 833–836, 2007.
14. Y.-P. Wuang, C.-S. Chiang, C.-Y. Su, and C.-C. Wang, "Effectiveness of virtual reality using Wii gaming technology in children with Down syndrome.," Research in developmental disabilities, vol. 32, no. 1, pp. 312–21, Jan. 2011.
15. A. Mitchell and C. Savill-smith, The use of computer and video games for learning A review of the literature The use of computer and video games for learning. London: Learning and Skills Development Agency, 2004.
16. P. Kearney, "Playing in the Sandbox: Developing Games for Children with Disabilities.," in Changing Views - Worlds in Play, 2005.
17. S. Battersby, "The Nintendo Wii controller as an adaptive assistive device–a technical report," HEA ICS Supporting Disabled Students through …, 2008.

Acknowledgments: The authors are grateful for the co-operation given by staff at the host school where much of the work was undertaken.

iED

Category: Paper

Immersive Installation: " A Virtual St Kilda"

Authors: S. Kennedy, John McCaffery, A. Miller, I Oliver, A. Watterson and C. Allison[1]

Affiliations: [1]School of Computer Science, University of St Andrews *alan.miller@st-andrews.ac.uk

Abstract: This paper discusses a Virtual Histories project, which developed a digital reconstruction of St Kilda. St Kilda is the most remote and western part of the United Kingdom. It was evacuated in the 1930s and lay empty for several decades. It is a world heritage site for both built and natural environment . The Virtual St Kilda acted as a focus for the collection and presentation of tangible and intangible cultural heritage. It was on show as an exhibition in the Taigh Chearsabah museum (Figure 5) located in North Uist Scotland. The exhibition is built around the OpenSimulator Open VirtualWorld server using commodity hardware. The simulation covers some 4 square km of virtual space, and models both tangible and intangible culture. It is integrated into an exhibition and articulates an interpretation of the St Kilda legacy through the prism of contemporary North Uist life.

Introduction: This paper discusses the use of Open Virtual World Technology to create an immersive museum exhibit of the St Kilda world heritage site. The exhibit has been enjoyed by thousands of people at the Taigh Chearsabhagh Museum and Arts Centre. It includes a 3D inter active model of St Kilda as it was in the late 19th century. The model is based upon archaeological evidence [emery96, harman88,harman96] and provides an accurate portrayal of both the geography and architecture of the Village Bay area of Hirta the largest island of the St Kilda archipelago.

St Kilda is a cultural and natural world heritage site. It is of immense interest both for its history and natural environment. Yet it is remote, requiring a four hour boat journey from the Outer Hebrides, consequently an exhibit which captures the spirit of the islands is an attractive proposition. The goal of this project was to make such an exhibit using open source software and commodity hardware. For this to work the exhibit had to be easy to use, reliable and capture the scale of the environment. The exhibit was to be unmanned. Therefore visitors had to be able to walk up and use it without training. Secondly, the exhibit had to run reliably for months without intervention, save being turned on and off at night. A key aspect of St Kilda is the size of the cliffs and surrounding hills and the relationship between human habitation, agricultural architecture and natural environment. To capture this a model which represented several square km of real space would be required. Further the exhibit was to integrate the many songs and stories which make up St Kilda's rich culture.

St Kilda is an archipelago about 40 miles west of the outer Hebrides, in Scotland. It is both the most western and the remotest land in the British Isles. Evidence has shown that St Kilda's history goes back at least as far as the bronze age. St Kilda's remoteness makes it entirely unique. The culture that developed there over the millennium during which it was inhabited is like no other culture in Britain. Similarly the natural life on the island is also a breed apart, literally in some cases. There are species of birds and mammals on St Kilda found nowhere else. St Kilda is

Figure 1: Panoramic View of Virtual St Kilda Main Street

also a place of great rugged, beauty. It is sheer rock rising out of the Atlantic, the last bit of land before you hit America. All these factors make it a place of fascination for many. It has been designated a UNESCO world heritage site for both its natural and cultural value. It is one of only twenty four such dual sites in the world and the only one in Scotland. As St Kilda is such a remote site, very few visitors will ever get to go there.

The archipelago consists of five islands (Soy, Boneray, Dun, Levenish and Hirte) and several sea stacks, including the highest stack on the British isles. Hirte, the only inhabitated island was evacuated in 1930. Villagers lived on the only street on the island (Figure 1), located on Village Bay. This street, known simply as `The Street' is lined with crofts, Blackhouses (traditionally Hebridean dwellings with thick walls and doors facing away from the sea) and Cleits (dry stone storage structures, unique to St Kilda, which cover the St Kildan landscape, more than 1100 in total. Village Bay is the closest thing Hirte has to a safe landing. Even in modern times poor weather makes it impossible for boats to offload cargo. When the island was still inhabited the islanders would sometimes go months, or whole winters, without receiving supplies from the mainland. All the factors that make St Kilda special also make it an excellent subject for a reconstruction. Its striking geography is something that can be hard to translate in still images or videos but translates well into being explored virtually. Visitors are unlikely to be able to experience it themselves. The stories that are linked to it interesting strike a universal chord.

The St Kilda model was developed in the first half of 2014. It is a technically challenging model, spanning 4 square km. This is orders of magnitude larger than is normal in OVW models. In order to support the larger size the client was modified to extend the far clipping plane of the view frustum. This enabled views that span from village bay out to the easily recognisable outline of Dun, to the south (Figure 2). Extending the visible area to include this greatly increases the sense of presence and ensures that the iconic vistas of St Kilda can be recognised immediately. The terrain data is taken from Ordinance Survey GIS information. The reconstruction covers village bay with objective to represent enough of the space such that, when standing in the centre of the village visitors get an accurate impression of the geography in all directions. Modelling focussed on the village itself, here the crofts, Blackhouses and Cleits are all modelled. The models for the Blackhouses and Cleits were developed in external modelling software and were both used as imported meshes and to create high fidelity images and videos using special effect software.

Figure 2: Virtual and Real Views of St Kilda, across village bay, looking out towards Dun.

The model is dated to the 1880s. The reconstruction has been augmented with a number of NPCs. Records from St Kilda are relatively complete so each NPC is named after a real inhabitant of village bay and their appearance taken from contemporary photographs. The model also features embedded content displayed as web pages. Throughout the model there are items which contain further information. These glow when the avatar approaches. When clicked on the viewer's inbuilt web browser displays a web page with text and images presenting information linked to the glowing object.

Development Process: The development of Virtual St Kilda was a collaborative process featuring an artist at the University of St Andrews (Sarah Kennedy), expert advice from the National Trust for Scotland (who manage St Kilda) and Access Archaeology, a community archaeological group on North Uist. Once the model was developed supporting material was produced with a range of collaborators, both local and national.

The first stage was to use GIS data to create the landscape in which reconstructions would sit. In St Kilda this is particularly important as the shape of the land is one of the most recognisable aspects of the site. The GIS data used is the Ordinance Survey high resolution data.

For the site to feel authentic accurate reproduction is vital. With the GIS landscape loaded measurements from the site were used to map out the location of every structure to be modelled. These measurements include Google Satellite view data, contemporary accounts and photographs and archaeological surveys. The site as it stands today is relatively unchanged. Several of the crofts have lost their roofs and there is now a modern base but otherwise the structures stand where they have stood since 1880. Having plotted the location of each structure surviving evidence of the site is surveyed as material to be integrated into the model. As part of this process areas of particular interest, recognisability or iconic status were identified. The date for the reconstruction is within the photographic era. Despite this there are still areas where no direct evidence is available showing precisely how it was in the past. In these instances more general evidence such as equivalent sites and written reports can be used to create a best guess at how that part of the model should look. As the model was developed there were meetings with experts from the National Trust for Scotland and with members of the Access Archaeology group in Uist to gather feedback. These meetings allowed expert interpretation to be incorporated into the development process. It is often the case that the ability to view an artefact, building or other element in its natural situation will allow theories to be tested and plausibility evaluated. As changes are relatively simple to make multiple different versions of the same feature can be created and experts use these to make a decision about what is most likely to

Figure 3: External view of Manse and Internal view of Blackhouse model.

be correct. In this way the iterative design cycle of the Virtual Time Travel Platform platform enables research into the heritage aspects of the projects. Views of NPCs inside a typical 1880s house and crops growing are shown in Figure 4. The outside of the manse church complex and the inside of the manse parlour are shown in Figure 3. The system architecture used to support this development is dicussed in some detail in [mccaffery2013] and an expansion of the reconstruction methodology can be found in [kennedy2013].

Once the model is created it is populated with content to help those who interact with it learn about the topic. This means adding multi media content and Non Player Characters. The model in turn is raw material that can be integrated into traditional media such as videos and still images, which can be distributed online or included in papers, newspaper articles and informational posters.

A set of videos was created as part of a program of community involvement. North Uist's links to St Kilda mean there is a wealth of material about the archipelago in the community. Many of the islanders have travelled to St Kilda and the video and images they brought back were made available for the project. Images shot on St Kilda were used to make posters for the exhibit and as part of the embedded web pages. Two separate Uist organisations, Uist Film and Island Voices, had produced films about St Kilda. The footage in these films formed the majority of the live action footage which was integrated with virtual footage to produce short videos about St Kilda. The rest of the footage was filmed as part of the project. In order to do this the Kilda Cruises organised a voyage to Hirte. Once there Qinetiq, the contractors who run the base, made transport available so that footage could be shot all over the island in a short space of time. Local groups of musicians, including the Gaelic singing teacher for the area, a ceilidh band group known as the Spring Chickens and children at local primaries, recorded pieces related to St Kilda. These were used in these videos. In the same primary schools pupils researched St Kilda and wrote narratives telling the stories they related to about their far flung neighbour. The childrens' tellings of these stories were recorded and combined with virtual footage and the other material gathered to tell some personal tales with a distinct North Uist voice. Community produced content was combined with National Trust for Scotland archive footage to illustrate some of the more historical aspects of the site. Technology students at a local college produced posters which advertise the exhibit. The National Trust also provided access to a recording of an interview with one of the last inhabitants of village bay. This interview was combined with virtual footage and footage supplied by local groups to create videos telling another form of story about life on St Kilda.

Figure 4: View of Cale growing in village bay and residents in post 1830 cottage.

Products of the community engagement include videos available online, streamed into the model and part of the St Kilda exhibit. These videos, as well as the posters that were produced and also the many events that were used to gather the material and share it with the community, help extend the reach of the project in directions that complement the model itself and ensure value in multiple contexts.
Records exist of who lived in what house during the time period. Linked with these names are historical documents photographs. Using this data NPCs where created to represent real inhabitants. These NPCs are scripted to walked through the town, performing the activities that would have filled the islanders days. These NPCs can interact with the user, they can speak, both in audio clips and through text. The research for the NPCs was helped by local knowledge, and by the National Trust for Scotland.

The Exhibition Space and Exhibit: The room in which the exhibit is installed is a large, barn like, room within the museum. The room is a cuboid space approximately 5m across, 15m deep and 6m high. There is no ceiling, just the beams which support the roof. The door is situated on the front wall, opposite the mezzanine balcony. The installation consists of a 3x1m poster along one wall, a projection covering the width of the front wall, coming down low enough to cover some of the door, a table with a 25" monitor and an XBox controller. The table is overlooked by a Kinect. Everything is controlled by a computer on the mezzanine level. This connects to a projector creating the projection and a wireless received for the XBox controller. The monitor receives its signal through a wireless HDMI kit. A powered USB cable runs from the mezzanine down to the Kinect.
The exhibit itself is made up of a series of short videos, ranging from two to ten minutes long, and a free exploration mode where the visitor uses the XBox controller to explore the model. The videos are intended as short, standalone pieces. They are designed with reference to the youtube format where information is presented in small sections but linked with more information so interested users can explore further if they wish. Videos cover subjects such as health on the islands, what Blackhouses and Cleits are and recordings of music with known links to St Kilda. There are also two longer videos. The first, `The Story of St Kilda' is a seven minute piece composed of a mix of real world footage and virtual footage introducing St Kilda and the different aspects that make it special and some information about the exhibit. The video has a voiceover narration each paragraph of information is narrated first in Gaelic and then English. The second long video is a ten minute long mood piece of the sights and sounds of St Kilda. This is designed to run when visitors have not started interacting with the system at all.

Figure 5: Taigh Chearsabhagh Museum and Arts Centre and Virtual St Kilda Exhibition..

The Blackhouse (https://vimeo.com/94504484) and Cleit (https://vimeo.com/99984295) videos combine renders, done using special effects software, with real world footage, shots from the main model and recordings of local residents performing St Kildan songs. The special effects shots integrate animated text and effects, such as smoke, into a high polygon mesh of the structure (Figure 7). The high poly meshes were then simplified and imported into the model. The modelling of the Cleits and Blackhouses was done by Alice Watterson and the animation by Alice Watterson and Keiran Baxter. The videos which tell general stories of St Kilda combine virtual footage and real footage. In these videos a static backdrop shot was filmed in the virtual world. Pupils from the local Cairnish primary school were recorded, twice, telling stories they had researched and written out about St Kilda. The first recording was audio only to get a clear recording. In the second a projector was used to cast shadows of the pupils over a white backdrop. This shadow footage was later manipulated in Blender to produce a pure black and white mask of their shadow. The final composite features the children's audio and their shadow projected over the virtual background. A frame from one of these stories is shown in Figure 8. Virtual shots of the larger used in the Blackhouse and Cleit videos, as well as in the `Guided Tour' are more dynamic than the static backgrounds of the stories. Camera movement's are programmed and then played back using Chimera. As they are played back the video stream from the computer is routed through an external device that can capture the stream to an SSD drive and simultaneously patch it forward to an output device. When camera movement is introduced any problems with framerate become readily apparent. The video is recorded at 30FPS so if the client is rendering fewer frames than this output smoothness is jeopardised. Another problem encountered in moving shots is tearing as the camera pans. To solve these problems Chimera's ability to record at a reduced speed is used. By recording the camera moves at 10\% or 1\% of the intended speed many frames of recorded material cover a single frame of intended output material. When the footage is sped up again samples across these multiple frames produce a much smoother final image than recording at full speed. This process produces smooth shots without the necessity of reducing graphical options to achieve an optimal framerate. To work all dynamic movement in the scene had to be slowed. This meant adapting scripts which make waves crash, birds circle and smoke sputter to operate at a reduced frequency and not appear hyperactive on the sped up footage.

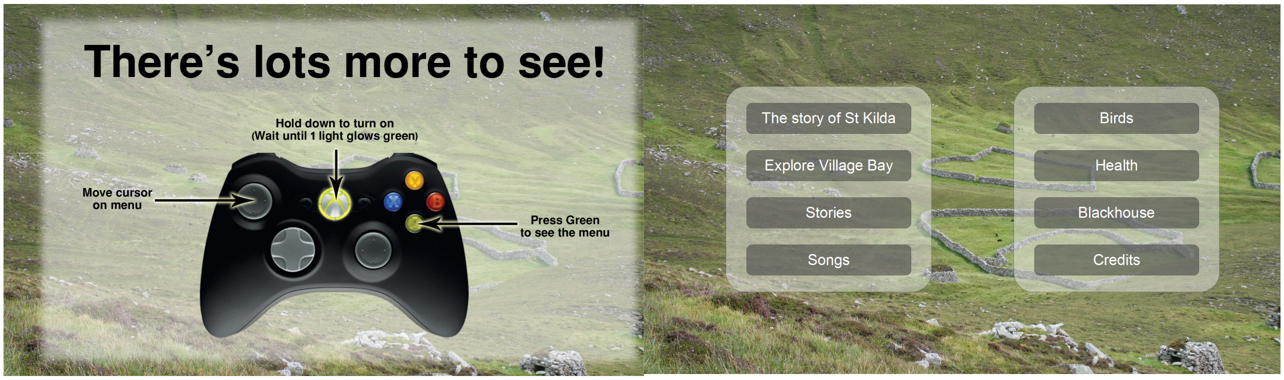


Figure 6: Instructions and main menu of the exhibit.

The exhibit is designed to run without the presence of a member of staff. When the first visitor of the day enters the room the exhibit is playing the mood piece on a loop. This remains until the visitor either moves to the back of the room or starts to press buttons on the XBox controller. When presence is detected in the room by a Microsof Kinect the Guided Tour is played. Once this has completed a notification appears telling the visitor that if they wish to explore further then can pick up the XBox controller and go to the menu (Figure 6). If they do not do this the Blackhouse video plays, followed by one of the recorded songs set to real world footage of St Kilda. Once this has completed the visitor is again prompted to engage with the XBox controller. If they do not more content is presented automatically. After a third prompt the exhibit will go back to playing the mood piece. If at any point the user does engage with the XBox controller they can press a button to go to the main menu. From the main menu, shown in Figure 6, they access all of the content in the model. To do so they use the joysticks on the XBox controller to move a cursor. When the cursor is hovered over a menu item for a couple of seconds that menu item is selected. Most menu items are made up of several videos, played back to back. Special cases are the option to explore the world directly and the credits. As well as prompts on the screen the exhibit also features laminated signs, instructing the visitor how to control it with the XBox controller. While the exhibit is generally designed not to require staff intervention members of staff will occasionally go into the exhibit and give tours of the content. In these tours they can highlight areas of interest to specific visitors and tailor the experience to the group. This format also means that visitors who might be put off by having to engage with technology can have a more directed experience than simply watching the automated content play.

A core design principle is community involvement. North Uist is a remote island with a relatively small population. Many people on the island have direct connections to St Kilda. Some have links to the people who once lived there, others work, or have worked there. In order for the exhibit to be received well and integrate into the environment where it was intended to be installed it was very important the local population took ownership of the project. The videos feature footage shot by local groups, recordings of local musicians and videos of local primary school students telling stories of St Kilda. Taken together this means that the exhibit is a combination of documentary and interpretation. Local, historical, academic and virtual all combine together to create something which is multi-faceted and tells the story of a unique place in a unique way all through a strong local voice. The end result is something that the community is happy to publicise to the world as their perspective on a site of international interest.

Figure 7: A frame from the Cleit animation and render of the inside of a blackhouse

St Kilda in Schools:
As well as installing the St Kilda scene as museum exhibit it was used as the basis for workshops across North and South Uist and Benbecula, known collectively as the `Long Island' Figure 10. These islands are three of Scotland's outer Hebrides. Workshops were done in three primary schools and in an adult learning centre. Two of the schools (Lochmaddy and Cairnish, both on North Uist) were primary schools with only a few dozen students across the 7 primary classes. The third was a larger primary school on Benbecula where students were streamed into Gaelic and English classes. In all schools a computer was set up with a projector and an XBox controller that pupils could gather round and watch content on.

In Lochmaddy one group, consisting of the older classes at the school, attended the exhibit. In Cairnish the pupils were split into two groups, younger and older. In both schools the pupils had been involved in the creation of the content and where excited to see themselves projected on the screen. Sessions in Lochmaddy and Cairnish started by showing the `Guided Tour' video, to introduce the material, and then showing the footage that the children had been involved in the creation of. Having seen the linear material the projector was switched to showing the virtual world and the children were given the opportunity to use the XBox controller to explore St Kilda. When exploring the children were prompted to take turns with the XBox controller, with all children not currently in control able to watch the projection and talk amongst themselves and to the child in control. This process was allowed to be relatively free, pupils were not forced to stay quiet and watch passively, they were encouraged to talk amongst themselves and to commentate on their experience. This lead to very enthusiastic sessions with much laughter and interaction. Pupils enjoyed being able to fly, especially when the ability to cease flying and watch the avatar fall from a height down to the ground was discovered. One of the consistent things that pupils enjoyed was attempting to find unexpected parts of the scene. Exploring underwater or trying to find houses which they were not supposed to enter and to get inside them.

Figure 8: A frame from the Lady Grange story. School students explore in stereoscopic 3D.

In Benbecula primary 6 students visited the workshop, split between the Gaelic and the English streams. Where the settings in Lochmaddy and Cairnish were relatively informal in Benbecula larger class sizes and older students required more structure. In Benbecula each class sat down and watched the `Guided Tour' video. Having watched the video they were split into two groups, with each group given access to a computer running the scene. In the groups pupils were encouraged to explore and think about questions such as `How many people do you think lived in the village?' and `What do you think it might have been living in such a remote place?'. Pupils were encouraged to share control such that everyone had a turn in charge of the avatar. After approximately twenty minutes the groups were relaxed and pupils had the opportunity to try out the Oculus rift. When pupils were initially given control there was some hesitance as to what they should be doing. All groups did explore the scene thoroughly. When the groups were relaxed and some pupils went to try the rift the noted tendency was for those to remain to focus more closely on the scene. Smaller groups lead to those with particular interests getting longer to investigate and familiarise themselves with the content.

Conclusion: This paper has described the creation of the Virtual St Kilda Exhibition. The exhibition provides insight into the lives of people who lived there in the 1880s. It enables appreciation of the relationship between the natural environment and human habitation, In doing so it enables visitors to make use of existing digital literacies to explore the past. Trough using commodity hardware and opensource software it has been possible to create an exhibit which captures both intangible culture the stories, songs and lives of the inhabitants and material culture the buildings and artefacts.

References:

[Emery, 1996] Emery, Norman 1996. *Excavations of Hirta* 1986-90. HMSO.

[Harman, 1996] Harman, Mary 1996. *An Isle Called Hirte.* MacLean Press.

[Kennedy et al., 2013] Kennedy, Sarah Elizabeth, Richard Fawcett, Alan Henry David Miller, Rebecca Jane Sweetman, Lisa Dow, Anne Campbell, Iain Angus Oliver, John Philip McCaffery, & Colin Allison 2013. *Exploring Canons and Cathedrals with Open Virtual Worlds: The Recreation of St Andrews Cathedral, St Andrews Day,* 1318. In Proceedings of UNESCO Congress on Digital Heritage. IEEE.

Figure 9: School students from Lochmaddy primary school.

[Stell & Harman, 1988] Stell, Geoffrey P, & Mary Harman 1988. *Buildings of St Kilda.* HMSO.

[Davies et al., 2013] Davies, Chris, Alan Miller, & Colin Allison 2013. *Mobile Cross Reality for On-Site Exploration of Cultural Heritage Reconstructions.* In Proceedings of the First International Congress on Digital Cultural Heritage.

[Dawson et al., 2013] Dawson, Tom, Anna Vermehren, Alan Miller, Sarah Kennedy, & Iain Oliver 2013. *Digitally Enhanced Community Rescue Archaeology.* In Proceedings of first International Congress on Digital Heritage.

[Dow et al, 2014] Dow, L.; Campbell, A.; Miller, A.; McCaffery, J.; Oliver, I. A.; Kennedy, S. & Allison, C. *An immersive platform for collaborative projects* Proceedings of IEEE Conference on Frontiers in Education, 2014

[Getchell et al., 2009] Getchell, Kristoffer, Alan Miller, Colin Allison, & Rebecca Sweetman. 2009. *Serious Games on the Move, chapter Exploring the Second Life of a Byzantine Basilica*, pages 165–180. SpringerWien.

[Getchell et al., 2010] Getchell, K., A. Miller, J. R. Nicoll, R. Sweetman, & C. Allison 2010. *Games Methodologies and Immersive Environments for Virtual Fieldwork.* IEEE Transactions on Learning Technologies, 3:281–293.

[McCaffery et al., 2014] McCaffery, J.; Miller, A. & Oliver, I. A. *Measurement of Immersive Technology for Historic Scenes* Proceedings of the 14th Eurographics workshop on Cultural Heritage, 2014

[Oliver et al., 2010] Oliver, Iain A., Alan H.D. Miller, & Colin Allison 2010b. *Virtual worlds, real traffic: interaction and adaptation.* In Proceedings of the first annual ACM SIGMM conference on Multimedia systems.

[Oliver2012] Oliver, I.; Miller, A. & Allison, C. *Mongoose: throughput redistributing virtual world* Proceedings of the 21st IEEE International Conference on Computer Communication Networks (ICCCN 2012) IEEE, International Conference on Computer Communication Networks (ICCCN 2012), 2012

[McCaffery et al., 2013] McCaffery, John Philip, Alan Henry David Miller, Sarah Elizabeth Kennedy, Anna Vermehren, C Lefley, & K Strickland 2013. *Exploring heritage through time and space: supporting community reflection on the highland clearances.* In Proceedings of UNESCO Congress on Digital Heritage. IEEE.

Category: Paper

Mobile Exploration of Medieval St Andrews

Authors: Adeola Fabola[1], Chris Davies[1], Sarah Kennedy[1], Alan Miller[1]* and Colin Allison[1]

Affiliations: [1]School of Computer Science, University of St Andrews *alan.miller@st-andrews.ac.uk

Abstract: Saint Andrews is a town with a rich history. It was the religious centre of Scotland for close to a millennium. The Cathedral was strongly associated with the wars of Independence and Robert the Bruce. The castle was the scene of pivotal revolt leading to the reformation and hosted the first Scottish protestant congregation. St Salvators chapel was the religious centre of Scotland's first University. This paper presents work which explores using mobile technologies to support investigation, learning and appreciation of the past. It builds on tradition and world class scholarship into the history of this important town and makes them available to school students, researchers and tourists using mobile technologies. From text based quests, through mobile apps to location aware stereoscopic 3D experiences the gamut of available commodity hardware is used to enable the past to be explored in new ways.

Introduction: Exploration of the past is often seen as a dry subject to be conducted with dusty tombs in dark libraries. Yet the widespread use of mobile and increasingly immersive technologies mean that new generations are more literate in the manipulation of digital data than ever before. These technologies and literacies can be put to use both to provide new insights into the past and to communicate established scholarship in ways that are accessible and engaging to new audiences.

The work described in this paper extends a Virtual Time Travel Platform (VTTP) [McCaffery et al., 2013] to support exploration of the past on mobile devices. The VTTP supports both the creation and deployment of 3D digital reconstructions of historical scenes. It is based on Open Virtual World Technology and has been engineered [Oliver et al., 2010] [Oliver2012] [Oliver & Miller, 2013] [McCaffery et al., 2014] to support real time interaction in large scale high fidelity environments using open source software and commodity hardware.

The reconstructions are based upon archaeological [Dawson et al., 2013] and historical evidence [Fawcett, 2011, Fawcett et al., 2003, Fawcett & Rutherford, 2011]. They model not just the physical scenes but tangible and intangible culture, both the fixtures and fittings of everyday life and the people together with their work, songs and stories. They enable engaging learning environments to be created which make sue of digital literacies developed playing games [Getchell et al., 2010].

This platform has formed the basis of installations in Museums, for example a reconstruction of the Scottish highland Caen township in the Timespan museum and arts centre. It has been used to enable school students at Madras college to explore reconstructions of the local St Andrews cathedral, has been used in higher education degrees in the arts [Getchell et al., 2009], social science [Ajinomoh et al., 2014] and the sciences [McCaffery et al,. 2014] and is accessible over the Internet [Dow et al., 2014]. In [Davies et al., 2013] a virtual time window system is described where mobile devices present a window into the past.

This paper presents and compares three modes of interacting with the past, it also describes the technologies which support the interactions. The Oculus Rift enables digital models to be appreciated in stereoscopic 3D. Here we present a system which enables physical exploration of a digital model, whilst occupying a parallel physical space. We describe the reconstruction of St Salvators chapel and its exploration using the Mirrorshades system. The QuestIt system guides a visitor through medieval St Andrews using texts sent and received by a mobile phone. This is complemented by a location aware app, which contains text, audio, graphics and video relevant to historic locations. This also provides access to the reconstructions.
We believe that the three modes of interaction are complementary to each other. Stereoscopic headsets provide a high quality immersive experience, text quests provide engagement and the app provide onsite access to multi-media context. Taken together they have the potential to revolutionise the way we interact with the past.

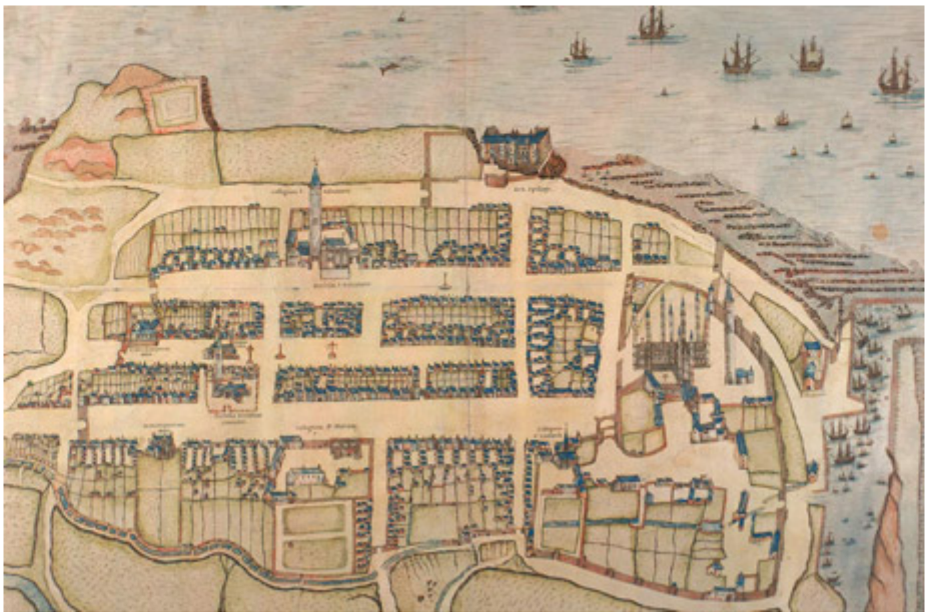


Figure 1: Contemporary View of Late Medieval St Andrews

Overview of Medieval St Andrews mobile learning app: This project brings together computer science, history and archaeology academics and students to create a Mediaeval St Andrews app. The Medieval St Andrews app will enable learners to concurrently explore the physicality of St Andrews and access location specific research. The app acts as a guide providing a narrative linking together specific locations on the physical trail. This encourages self-paced student centred learning. For each point of interest on the trail text, images, audio and video, combine with the physicality of the location to provide an engaging learning experience that motivates further reflection. Links to online digital resources, which index relevant scholarly research guide further investigation. In this way new research learning linkages are created. Smart phones and tablets are becoming ubiquitous and have the functionality to add a new dimension to learning. They typically contain GPS, a high resolution screen and connect to the Internet. The Medieval St Andrews App, enables the synthesis of scene and discourse in the learning process. Until now the cost of app authoring has been too high for this technology to be integrated into infrastructure of learning in higher education. This project demonstrates the educational value of integrating location into the learning process and has developed a framework for educational app creation.

St Andrews is a town central to Scottish and world history (Figure 1). Robert the Bruce attended the consecration of St Andrews Cathedral (Figure 4), whilst the diocese funded him through the wars of independence. St Salvators dates from the foundation of Scotland's first University (Figure 9, 10, 11, 12). St Andrews was a driving force for the reformation with the Castle being home to Scotland's first protestant congregation. Evidence of this rich history is interwoven with the fabric of the town.

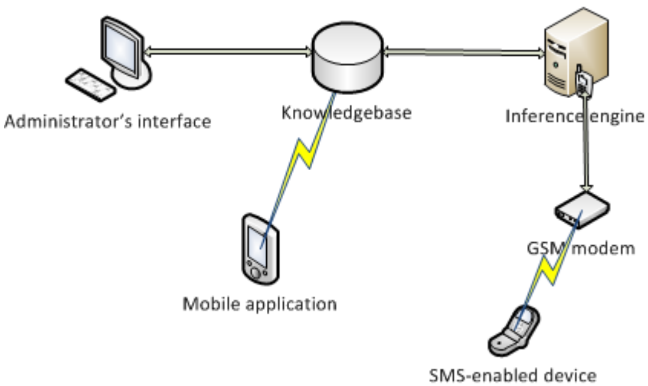


Figure 2 QuestIt System Design

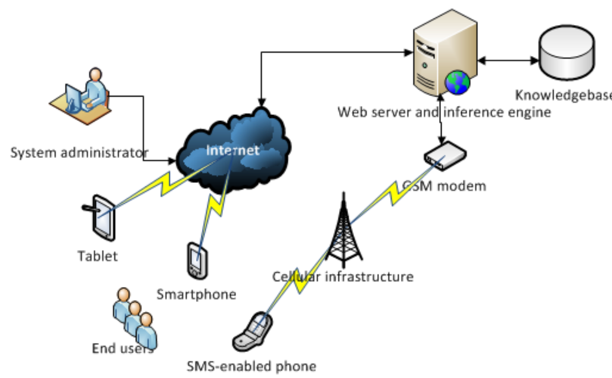


Figure 3 Conceptual Architecture

There is a rich potential for further location aware learning apps. Within St Andrews: History of the University, Witches Tour, the Books of St Andrews, Churches of St Andrews and History of Golf are examples. This approach is also valuable across disciplines with relevance in history, art history, classics and divinity, location aware apps will also enhance virtual fieldwork in geography, geo-science and ecology. The design and creation of apps currently attracts a premium. Single apps may cost between tens and hundreds of thousands of pounds to commission. We propose a generic format, abstracted from existing apps, which will support multiple disciplines and applications.

A welcome page with embedded photograph and image map provides a visually striking introduction. At the heart of each app is a zoomable interactive map. A user's location and clickable points of interest are represented. Each point of interest may have text, images, audio, video and a 3D model associated with it. These stimulate interest and act as gateways pointing to further learning and research materials.

We have designed a web user interface which enables app content to be easily created and updated. A simple form enables upload of the front page image and definition of menus. The live map area is defined in OS coordinates, if required a custom map may be uploaded. Points of interest are defined by entering OS co-ordinates. Each point of interest is then associated with text, images, audio and video as appropriate. This interface enables students to create apps enabling co curriculum development of communication skills and engagement with professional publication issues. Once the content for the app is defined open source tools allow automatic compilation for IOS, android and other platforms.

This project draws upon scholarship and student input in the schools of History, Art History and Classics. It marries the teaching and research agendas of staff in the Institute of Mediaeval Studies (SAIMS) and in the Institute of Scottish Historical Research (ISHR) which supports the umbrella project and teaching portfolio of Mediaeval St Andrews. It will make accessible reconstructions of St Andrews Cathedral (https://vimeo.com/77928887), St Andrews Castle and St Salvators chapel.

Figure 4: Reconstruction of St Andrews Cathedral 1318

Texting: This section discusses the considerations and activities that went into the design phase of the system. There are two main user groups for the system: System Administrators: These are computer-literate staff of cultural heritage organisations. They will interact with the system through a web interface that provides functionality to populate the knowledgebase with heritage information as well as additional features to modify this information and monitor end user transactions. End Users: These are tourists, passers-by and members of the general public that are interested in learning about the cultural heritage of a given locality. They interact with the system by sending and receiving SMS messages on their mobile devices, and by using the mobile application developed.

The system is made up of the following five components. The knowledgebase: A structured repository that holds all the information used by the system. The SMS inference engine: A set of rules for making deductions based on the contents of the knowledgebase. The GSM modem: A modem that facilitates the receipt and sending of SMS messages from and to users respectively. The administrator's interface: A web interface that provides administrative functionalities such as creating trails, modifying trails and viewing records of SMS transactions. The mobile application: An application that users can download onto their mobile devices (smartphones, tablets, PDAs) to take their learning experience further.

The architecture of the system is shown in Figure 2 and Figure 3. System administrators and end users access the administrators interface and the mobile application respectively over the Internet. However, the SMS functionality of the system is accessed over the cellular (GSM) infrastructure and works independent of Internet access. The GSM modem is connected to an inference engine (which can be configured, started and stopped by the system administrator) connected to the knowledgebase.

An inference engine was developed in Java to facilitate connectivity between the GSM modem that sends and receives SMS messages from users and the server that the modem is connected to. The GSM modem used is the Wavecom Q2303A Module USB GSM Modem. An open-source Java API (SMSLib) was employed in the development of the inference engine to facilitate the AT command-driven communication between the server and GSM modem. This API was then leveraged by writing Java methods and classes to enable the server establish communication with the connected modem, instruct the modem to read incoming messages in real-time as they are being sent by users, generate appropriate responses based on the contents of the received messages, and automatically send those responses to users.

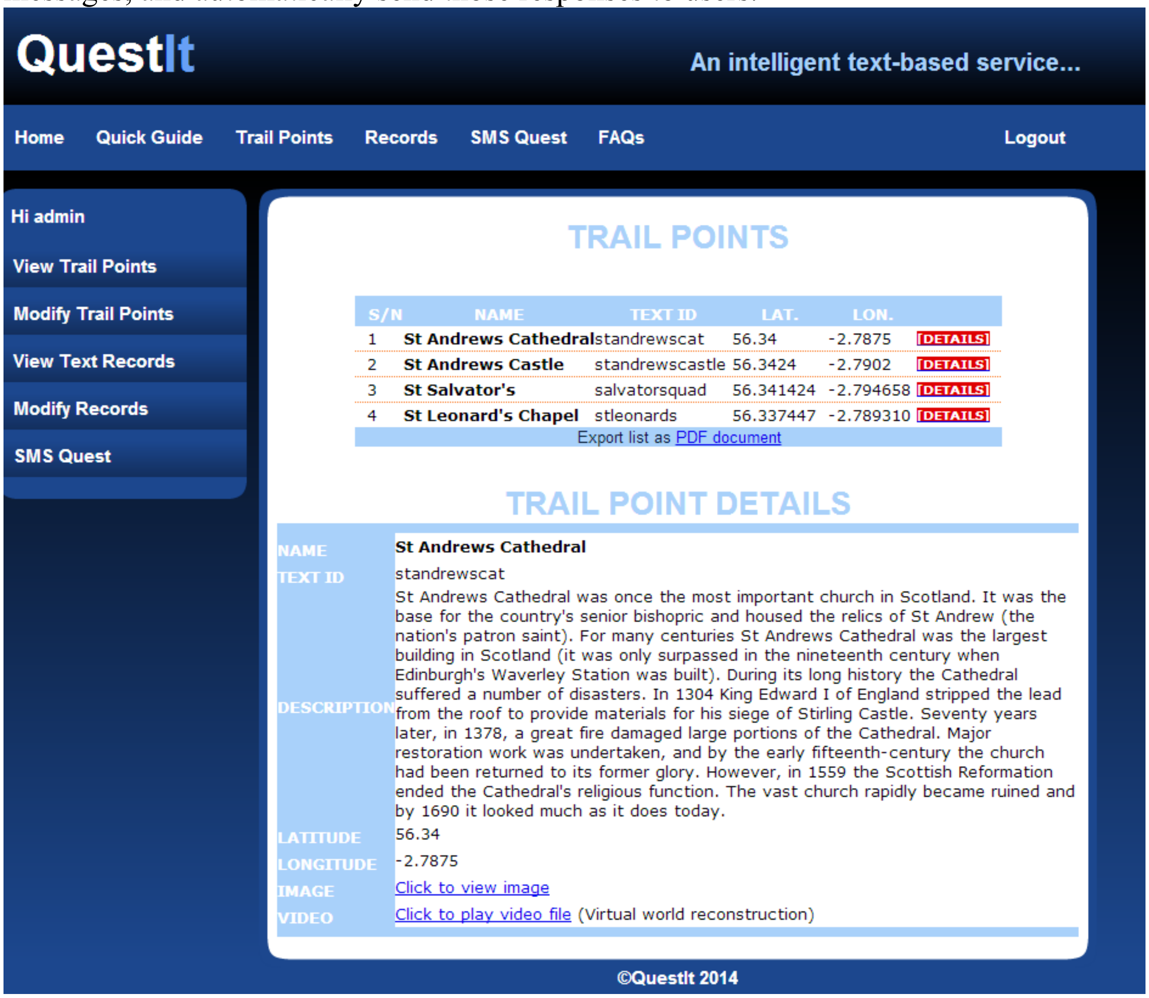


Figure 5 QuestIt Administrators Interface

The following steps take place when a user sends an SMS message to the mobile number controlled by the GSM modem:

User sends SMS message containing text string.

- Modem receives SMS message asynchronously and generates a notification to the inference engine.
- Inference engine connects to the knowledgebase and searches for the text string in stringid column of the trailpoints table. If a match is found, inference engine retrieves the content of the description column of the trailpoints table and stores it in a temporary variable. If no match is found, inference engine generates an “unrecognised string” message and stores it in temporary variable.
- The inference engine instructs the modem to send the contents of the temporary variable as an SMS to the user.

- Modem sends the appropriate response to the user.

The inference engine stores the transaction details in the records table and updates the users table of the knowledgebase.

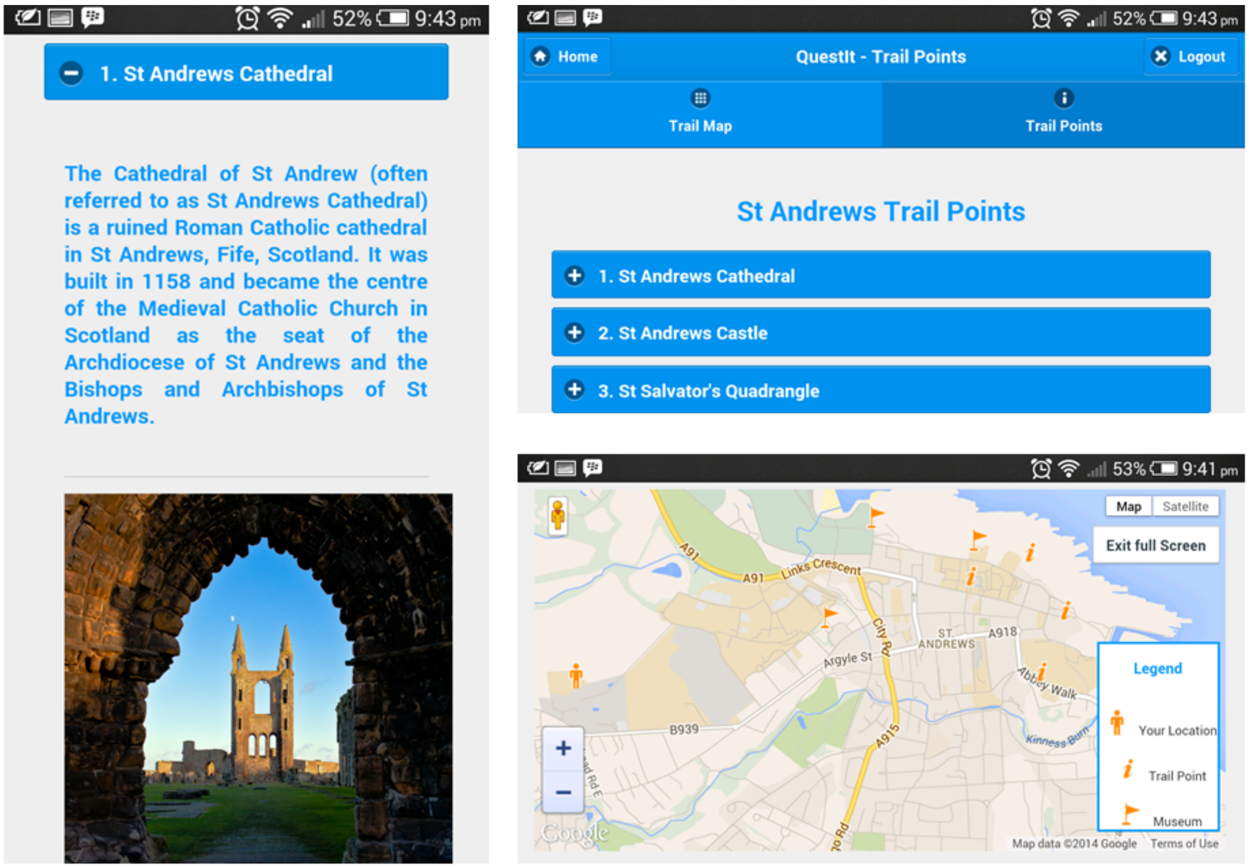


Figure 6: Screen shots from the App

Administrators Web Interface: To ensure accessibility and ease of use, the administrators interface was designed using web technologies and hosted on a server accessible over the Internet. This interface took the form of a dynamic website designed using PHP (for the server-side scripting) and HTML, Javascript and CSS for the client-side. The interface contains functionalities to create trails by adding (as well as deleting and modifying) a series of connected trail points and keeping track of end user usage by viewing records of SMS transactions. When adding a trail point, an administrator specifies the name (e.g. St Andrews Cathedral), a unique string identifier (e.g. "standrewscat"), a description of the trail point (history, important features, current state and so on), the latitude and longitude coordinates (e.g. 56.34, -2.7875), any additional text (e.g. riddles, quests or quotes associated with the trail point) and may choose to upload additional resources like images (pictures of the trail point), audio files (songs or stories associated with the trail point) and video files (ancient footage or virtual worlds reconstruction of the trail point). Once the submit button is clicked, the information specified is validated and then stored in the trail points and resources tables in the knowledgebase, and will appear as a trail point in the administrators web interface. The interface also features a brief introduction and guide on how to use the system and a page devoted to Frequently Asked Questions (FAQs).

Mobile App: A mobile application has been developed to take users' experience further by leveraging the features and capabilities of smartphones to deliver interactive and engaging contents to users (Figure 6). To ensure accessibility across multiple mobile platforms (Android, IOS, Windows Mobile, Blackberry, Symbian and so on), PhoneGap was leveraged to build a mobile application using Javascript, HTML5 and CSS3 and then compile the codes for these platforms.

Figure 7: App Front

Figure 8 Using Mirrorshades X Reality System

The mobile application connects to the MySQL knowledgebase and reads the contents of the trailpoints and resources tables. This communication is facilitated in Javascript by generating JSON (JavaScript Object Notation) and AJAX (Asynchronous JavaScript and XML) requests to PHP scripts (hosted on an online server) which make SQL queries to the knowledgebase, retrieve data and send the data (encoded as JSON objects) to the client device. The contents of these tables (which represent connected trail point entities and informative resources associated with these entities) are then visually represented in the mobile application in form of a heritage map view and a trail points view. The map view features a series of clickable icons that represent three categories of entities – heritage trail points (e.g. St Andrews Cathedral), heritage organisations (e.g. Museum of the University of St Andrwes) and the user's location (represented by the coordinates of the user's mobile device) – all on a live map sourced from googlemaps API . The map view allows users to view the locations of trail points and heritage organisations respective to their locations, and interact with a heritage map of the given locality by panning, zooming and clicking on icons to gather more information. The location of each trail point icon on the map corresponds to the latitude/longitude coordinates specified by the system administrators when creating the trail point using the web interface, and when a trail point icon is clicked, users are directed to the trail points view which displays information and resources about all trail points while highlighting the particular trail point clicked on. The information displayed for each trail point correspond to the contents specified by the system administrator when creating the trail point (using the web interface) and includes a description, one or more images, audio, video, riddles, quotes, puzzles, latitude/longitude coordinates as well as a button that displays the location of the trail point on the map view when clicked. Both the map view and trail points view have buttons that users click to change their view (e.g. navigate from the map view to the trail points), as well as buttons to toggle full screen mode, navigate to the welcome screen point and log out of the system. The following steps outline the flow of information between the administrators interface, mobile application and system resources:

- System administrator creates trail points, specifying the name, description, coordinates and multimedia resources using web interface.
- Trail points are stored in the knowledgebase.
- User with a smartphone or tablet launches the mobile application and mobile application makes JSON request to PHP script on a web server.
- PHP script queries trailpoints and resources tables of knowledgebase using SQL statements, encodes the retrieved information as JSON objects and transmits the objects.
- Mobile device receives JSON objects, formats them using JavaScript and visualises them on an interactive map view and trail points view.

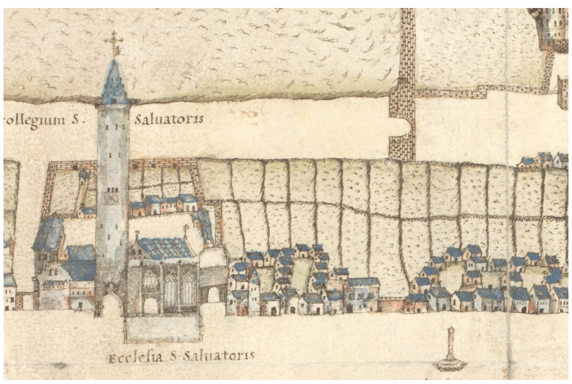


Figure 9: St Salvators Geddy View

Figure 10: St Salvators Reconstruction

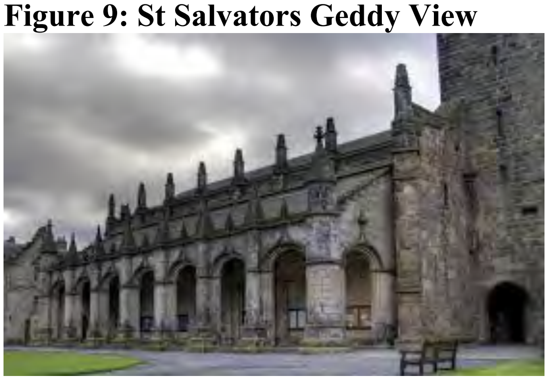


Figure 11: St Salvators Today

Figure 12: St Salvators Stereoscopic Altar

Into the third dimension with Mirror Shades: We have created 3D reconstructions of a number of medieval buildings in St Andrews. These reconstructions have been used in schools and public exhibitions to provide a new perspective on the past. Users are able to explore these reconstructions through the proxy of an avatar controlled by a key board and mouse or games controller. The models contain interactive content and non-player characters representing personalities from the past such as Robert the Bruce and Cardinal Beaton. These models have also been used to enrich mobile exploration of St Andrews. Images and videos of the reconstruction provide content for the text trails which may be accessed through Web references. The app also has 3D content linked into it. Images of the reconstruction enable comparison with the present day sites as well as with images from the past such as the Geddy map. Videos such as (https://vimeo.com/77928887) enable guided tours of the reconstructions to be followed whilst on site. These provide a valuable but cut down experience of 3D reconstruction but have the benefit of being available on site.

The Mirrorshades cross reality system is based upon the Oculus Rift, Web Cams and an indoor positioning system. This enables users to walk around the current day site of St Salvators Chapel and simultaneously to see the reconstruction of the chapel in stereoscopic 3D. This gives an immersive experience far superior to viewing via a traditional monitor. A challenge for this sort of cross reality system is how to overcome the ``vacancy problem'' where the user is cognitively present in one reality but absent from the other. We overcome this problem in part by automating navigation. As the user moves around the real space their viewpoint in the virtual space is changed automatically. The user is also able to easily switch between realities at any time. The video cameras provide a view into the real whilst the simulation provides a view into the past. In this way the user is freed to explore the past and to compare it to the current site.

This video shows the mirror shades system in use during an evaluation session where it is used for mobile exploration of St Salvators Chapel.

Mirrorshades has been used to enable comparison of St Salvators chapel as it is today and as it was in the 15th Century. System performance measurements showed that framerates of between 40 and 40 fps were achieved, that latency from cameras was around 180ms and that user position was tracked to within a few meters whilst moving and to within a meter whilst stationary.

An X-Box controller enabled users to switch between realities, by pushing a button or puling a trigger. There was a preference for alternating between real and virtual rather than viewing both simultaneously. The virtual was viewed more while stationary and the real was moving. The combination of easy switching and intuitive navigation effectively addressed the vacancy problem enabling easy comparison between the two realities. The strength of the immersive experience provided by stereoscopic vision, compensated for the low specs, in terms of framerate, resolution and accuracy of movement tracking provided by the system. All users found the experience to be extremely positive, enjoyable and informative.

Conclusion: This paper has outlined three approaches to mobile exploration of Medieval St Andrews. In each case users are able to explore the past and to compare reconstructions and historic images with present days site. The text approach has the advantage of simplicity, intimacy and low tech requirements. Digital literacies exist across the population with respect to texting. Also texts are often seen as high value communication items. The system enables the creation of Quests, where the user progresses from site to site.

The predominance of smart phones equipped with multimedia capabilities, broadband and geo-location systems under pines the creation of the St Andrews Medieval app. A visitor or student is able to locate points of interest that are close to them, receive directions on how to reach the point of interest and access a wealth of material about the site. This will include audio commentary, images and text. A valuable aspect of the app architecture is the inclusion of a web interface which enables the content to be created by filling in forms and uploading files. Consequently given appropriate content it is possible to create a trail app in a short period of time without specialist skills. The third mode of exploration Mirrorshades, enables a fully immersive experience to be achieved on site. The system addresses the vacancy problem and facilitates rich comparison of the present day with the past.

References:

[Ajinomoh et al., 2014] Ajinomoh, O.; Miller, A.; Dow, L.; Gordon-Gibson, A. & Burt, E. Helfert, M.; Martins, M. J. & Cordeiro, J. (Eds.) *Managing Humanitarian Emergencies - Teaching and Learning with a Virtual Humanitarian Disaster Tool.* CSEDU (1), SciTePress, 2012, 55-6

[Davies et al., 2013] Davies, Chris, Alan Miller, & Colin Allison 2013. *Mobile Cross Reality for On-Site Exploration of Cultural Heritage Reconstructions.* In Proceedings of the First International Congress on Digital Cultural Heritage.

[Dawson et al., 2013] Dawson, Tom, Anna Vermehren, Alan Miller, Sarah Kennedy, & Iain Oliver 2013. *Digitally Enhanced Community Rescue Archaeology.* In Proceedings of first International Congress on Digital Heritage.

[Dow et al, 2014] Dow, L.; Campbell, A.; Miller, A.; McCaffery, J.; Oliver, I. A.; Kennedy, S. & Allison, C. *An immersive platform for collaborative projects* Proceedings of IEEE Conference on Frontiers in Education, 2014

[Fawcett, 2011] Fawcett, Richard 2011. *The architecture of the Scottish medieval Church.* Yale University Press.

[Fawcett et al., 2003] Fawcett, Richard, Sally Foster, & C. J. Tabraham 2003. *St Andrews Cathedral.* Historic Scotland.

[Fawcett & Rutherford, 2011] Fawcett, Richard, & Allan Rutherford 2011. *Renewed life for Scottish Castles.* Council for British Archaeology.

[Getchell et al., 2009] Getchell, Kristoffer, Alan Miller, Colin Allison, & Rebecca Sweetman. 2009. *Serious Games on the Move, chapter Exploring the Second Life of a Byzantine Basilica*, pages 165–180. SpringerWien.

[Getchell et al., 2010] Getchell, K., A. Miller, J. R. Nicoll, R. Sweetman, & C. Allison 2010. *Games Methodologies and Immersive Environments for Virtual Fieldwork.* IEEE Transactions on Learning Technologies, 3:281–293.

[McCaffery et al., 2013] McCaffery, John, Alan Miller, Anna Vermehren, Carolyn Leffery, & Keir Strikland 2013. *Exploring Heritage through Time and Space: supporting community reflection on the highland clearances.* In Proceedings of the First International Congress on Digital Cultural Heritage.

[McCaffery et al., 2014] McCaffery, J.; Miller, A. & Oliver, I. A. *Measurement of Immersive Technology for Historic Scenes* Proceedings of the 14th Eurographics workshop on Cultural Heritage, 2014

[McCaffery et al,. 2014] McCaffery, J.; Miller, A.; Oliver, I. & Allison, C.*Augmented Learning Roads for Internet Routing* Proceedings of IEEE Frontiers in Education, 2014

[Miller et al., 2013] Miller, Alan, Lisa Dow, Sarah Kennedy, & Richard Fawcett 2013. *Exploring Cultural Heritage with Open Virtual Worlds: the reconstruction of St Andrews Cathedral in OpenSimulator.* In Proceedings of the International Congress on Digital Herritage.

[Oliver et al., 2010] Oliver, Iain A., Alan H.D. Miller, & Colin Allison 2010b. *Virtual worlds, real traffic: interaction and adaptation.* In Proceedings of the first annual ACM SIGMM conference on Multimedia systems.

[Oliver2012] Oliver, I.; Miller, A. & Allison, C. *Mongoose: throughput redistributing virtual world* Proceedings of the 21st IEEE International Conference on Computer Communication Networks (ICCCN 2012) IEEE, International Conference on Computer Communication Networks (ICCCN 2012), 2012

Category: Paper

A Contribution to Collaborative Learning Using iPads for School Children

Martin Ebner[1,]*, Benedikt Kienleitner[1]

Affiliations:

[1]Social Learning Department, Graz University of Technology, Austria

*martin.ebner@tugraz.at

Abstract:

Collaboration has a very positive effect on students' learning experiences as well as their social interactions. Our research study aims towards enhancing the learning experience, stimulating communication and cooperative behavior to improve learning. Making use of recent technological advancements (tablets) and gaming as a motivational factor, a prototype application in form of a multiplayer learning game for iPads was designed and developed. In a face-to-face setting, connecting up to four devices, the players (learners) have to solve word puzzles in a collaborative way. Furthermore, a web-interface for teachers provides the possibility to create custom content as well as to receive feedback of the children's performance. A first field study at two primary schools in Graz showed promising results for the learning behavior of school children.

One Sentence Summary: This publication introduces a mobile application for iOS with a special focus to foster collaboration among learners.

Introduction

The last decade has provided us with amazing new and innovative technological possibilities. Wireless networks and mobile devices have become omnipresent, opening countless new ways to deliver content and exchange data. On the software side, Web 2.0 [32] has changed the way we interact with websites. Beyond private use, the potential of those technologies for schools and educational purposes is arbitrarily [5] [4]. Computers, and tablets in particular, offer a perfect opportunity to present learning material in a more playful manner. Under the right circumstances, education with learning games can have many benefits [27]. Educational games exist in many forms, however, only a handful of games could be found that focus on the aspect of communication and cooperation among peers. Numerous studies [18] have demonstrated that collaborative learning can have a positive effect on social behavior as well as learning results and communication abilities [20] [17]. Due to the fact that learning is an active part of the learner where knowledge and understanding is constructed by the learner him/herself [12], communication and collaboration are essential factors along this process [36]. Learning is a highly social process and develops through conversation [2] [28].

Research Goal

Focusing on the aspect of cooperation and collaborative learning, the research goal is to use digital devices to connect the learners to strongly assist the communication between peers. The fundamental idea is to develop a prototype-application where learners can actively engage into collaborative work.

During the course of the following pages, we will present theoretical background and experiences on cooperative learning with mobile devices, the design and the technical implementation of our application and finally the results of the first field study in two primary school classes.

Theoretical Background

This chapter provides information on collaborative learning, educational games and the use of mobile devices in classrooms.

Collaborative Learning

In simple terms, collaborative learning can be described as a situation in which two or more people attempt to learn something together [3]. They will ask each other for information, evaluate one another's ideas and monitor one another's work [1]. The benefits are an increase in students' engagement and their motivation to learn as well as a deeper understanding of learning material [35] [29]. Furthermore, as a result of collaboration and communication among peers, an improvement of students' interpersonal relationships was noticed [18].

These effects, however, do not automatically appear when students are placed together in groups. For cooperative learning to occur the groups and learning activities must be carefully chosen [19] [24].

Educational Games

Information technology has changed the way we work, live, learn and entertain ourselves. A new generation of students has emerged, their learning preferences tend toward teamwork, experimental activities, structure and the use of technology [37].

Outside school, computer games have become an integral part of young people's live, holding a special fascination and provoking a deep sense of engagement [26]. The motivational aspect of gaming can be combined with curricular contents by creating games with educational purpose. Learning in that matter is researched to be more learner-centered, easier, more enjoyable, interesting and thus more effective [21] [33].

Games can constitute powerful learning environments for a number of reasons [31]:

- They can support multi-sensory, active, problem-based learning.
- Games favour activation of prior knowledge. Players must use previously gathered information in order to advance.
- They provide immediate feedback, enabling players to learn from their actions.
- They offer opportunities for self-assessment through the mechanism of scoring and reaching different levels.
- Games are often social environments. They can be played with others and involve large communities.

Today there are numerous research studies carrying out the idea of using games for learning [40] [11] [6] [7] and pointing out how learning can be improved through using the three crucial factors: curiosity, fantasy and challenge [26].

Mobile Devices in Classrooms

Mobile devices have become an integral part of our lives. Students are already using personal devices for learning outside of school as recent studies pointed out [16]. This raises the question: Will students who come to expect mobile personal devices outside of school demand to use them within school?

There are two key factors for the use of mobile devices in classrooms [25]:

- One personal device per student.
- A communication network that supports peer-to-peer connections and/or internet connectivity.

In such an environment, handheld devices can have numerous educational benefits, a few of them are listed below [23]:

- Portability. The ease of movement with the device creates learning environments that have not been possible before.
- Social interactivity through wireless communication. Peer-to-peer communication makes data exchange, face-to-face interaction and collaboration possible.
- Connectivity, establishing a shared environment for data collection among distributed devices.

In recent years there has been a trend towards an integral use of handheld devices in classrooms instead of the occasional visit of computer labs [13]. Portability and peer-to-peer connectivity make them a perfect choice to assist cooperative learning approaches. Thus, the collaboration of students through different mobile devices has become an import research issue. Studies demonstrated that mobile technology can aid or actively support collaboration [41]. Nevertheless, the idea of a collaborative learning game for and through mobile devices, specifically developed for the use in school classes, is a rather new one.

Idea and Concept

TU Graz has been developing learning applications for iOS for several years, already starting in 2010. A number of workshops have been given on app design and how to achieve users' satisfaction [8]. In addition, several studies have provided valuable insights in the design of applications for iPads in school classes. Two points that should be improved stood out above the others [14]:

- Missing feedback for teachers. Mobile applications are usually standalone programs and learning takes place as an interaction between the student and the application, excluding the teacher from the process. There is no possibility for the teacher to get insight into a pupil's performance, how many exercises are done or if the learning goals are achieved.
- Lack of collaboration. Mobile devices provide unprecedented possibilities to enable and assist cooperation and collaboration. While current learning

applications are able to enhance individualised learning, developers of mobile learning apps seem to have taken no special interest in this area.

Building on these insights, the fundamental idea of this research study is to develop an application where learners actively engage into collaborative work and to combine this with the benefits inherent to games. Furthermore, a web-based application has to provide an interface for teachers, so that they will be able to receive feedback of the pupils' performance and to create their own learning content fitting to the curricula of their class.

Methodology

Our research study is split into two parts. The first step is the development of a first prototype application and website, the second one a field study to test and evaluate the prototype both from a technical perspective as well as a pedagogical one. So it is clearly stated that our research methodology is a strong application-oriented one based on the proof-of-concept principle. The intended application is a cooperative multiplayer learning game for iPads, the website a user interface for teachers to create custom content and to monitor the children's performance.

The field study took place at two primary schools in Graz. In form of a participatory observation, the application was tested in two so called "iPad classes" (second grade primary school). Each trial took about 60 minutes. After a short explanation of the app, the children were split into groups of two. Assisted by the teacher and a research assistant, the children used the app for about half an hour. When they seemed to be familiar with the game, they were split into groups of four and left to play for the remaining 30 minutes.

The trials were documented by the participating research assistant as well as the teachers, focussing on the aspect of cooperative usage and technological challenges.

After the test, interviews with a selected number of children, one of each group of players, were performed to understand their feelings about the application.

Idea and Concept

"Buchstaben Post"[1] is a learning game for schoolchildren between grades 1 to 4. The aim is to teach children the correct spelling of words with a focus on collaboration and communication between the players.

The idea can be described as following: Connect up to four mobile devices (tablets) in a peer to peer session. While it is still possible to play alone, it is intended as a multiplayer game with 2 to 4 people. To achieve a level of cooperation, all players have to work together to progress to the next round. The teammates are supposed to sit on the same table. The tablets are placed beside or in front of each other, resembling the setting of a classical board game. Figure 1 is a representation of such a game setting with four players, respectively four iPads, placed in front of each other on the same table. All players are able to see the content of the game, as described later on, displayed on all tablets, so they are able to help each other out in several ways. They can either aid by discussing the solution or actively take action by reaching out and interacting with the iPad of a teammate. This is a unique setting, establishing a level of social interaction and the ability to work together that has not been possible before with digital devices. It is a great display of the advantages of tablets or mobile devices over conventional personal computers or even notebooks.

1 https://itunes.apple.com/de/app/id736836885?mt=8 (Last visited: Nov. 2013)

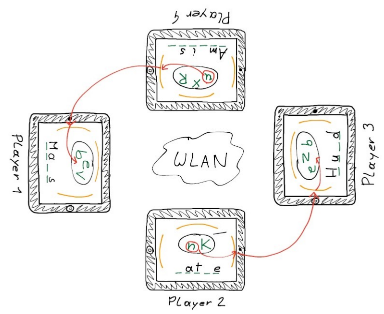


Fig. 1. Game Setting

The second part of the application is the user interface for teachers. Many current learning games are too general regarding their content and lack a connection to curricula in school [9]. Therefore, it is important to provide teachers with the opportunity to create custom content for their children and to receive feedback. Especially school children in the first grades are only able to read or write a limited number of different words, so the difficulty of the game has to be adjustable to fit the curriculum of the school classes. For this purpose, a user interface for teachers in form of a website has been developed.

Technical Framework

"Buchstaben Post" is a native iOS application, for iPads only. As a programming language, Objective C was used. The user interface for teachers was implemented in HTML and PHP. MySQL was employed as database management system.

User Interface Design of the App

When developing software for children, special care has to be placed in designing the user interface of the application. Factors besides usability and functionality have to be considered. Aesthetics are part of an overall enjoyable user experience [22]. In addition, colour and its manipulation are an important aspect for visual interfaces [38]. In general, it can be said that emotion plays a large part in our interaction with objects [30]. The app is intended for the use in primary schools. At this age, children are reading slowly and are still learning to write. They will have limited domain knowledge [15] and difficulties with typing using a keyboard [39]. Those considerations had to be taken into account, especially regarding the design of the login and connection views.

Children's fine motor skills are different than those of adults. Studies regarding pointing tasks have shown that children's performance is below adults by several degrees. In most cases the target size had a significant effect on children's accuracy [15].

Furthermore, children will have difficulties with thinking abstractly [34]. Thus, menus and similar navigation elements should not contain abstract concepts and metaphors have to be carefully chosen. However, images better match children's cognitive skills than written words [10].

Regarding learning applications, we could build upon insights gathered from several workshops at TU Graz, which have been summarized in the iPad Human Interface Guidelines [8], as well as the extended guidelines focusing on mobile learning [14].

Connecting the Devices

Establishing a peer-to-peer connection is another challenge, from the technical perspective as well as from a design point of view. The game is intended for school classes where each pupil is in possession of his own personal tablet device. While the children might have acquired a general proficiency in using the operating system, they will not have a concept of how a WLAN or Bluetooth connection works, or, for that matter, how the devices are connected at all.

To address the problem, the application is able to connect over WLAN as well as Bluetooth. If one method is turned off or not able to establish a connection, the application will automatically try to connect over the other medium. Luckily, the iOS Gamekit framework supports that kind of connection management. Only the interface had to be adapted for the use of children.

Description of the iPad App and Website

As mentioned before, the game can be played in single player mode. If that's the case, the goal of the game is simply to guess the correct spelling of a word. A hint in form of a sentence or a question and a number of letters are provided. The player has to substitute the missing letters of the word to guess. This is a well-known concept which already exists in numerous applications. The idea is to use that approach and expand it in a way that allow to create a multiplayer application, where players not only had to guess their own words, but help each other out as well.

The game is not competitive, which means that the players are not "punished" for choosing a wrong letter, they can try as many times as they want. The game will not progress to the next round until all players have finished their words. Since it is meant to be played in a face-to-face setting, all players should be able to see the words of their teammates. Children who finish faster are thus able to help others out. In order to further reinforce the idea of a "common goal", we provided another challenge for the players. While some players may possess all the missing letters of their word, other players will not be so lucky – they have to get the missing letters from one of their teammates.

The following section provides a more detailed explanation of the game mechanism.

The User Interface and Features

The game is composed of four screens, not counting the splash (or loading) screen.

Figure 2 shows the start screen of the game. To keep it as simple as possible only two options are available – new game or join game. After choosing one, the player will be asked to sign in. This opens a login form, as depicted in figure 3.

Fig. 2. Start Screen.

Fig. 3. Start Screen with Login Form.

To log into the game, an account at the TU Graz user-management2 system is required. While it is possible to play offline, the sign in is required for several reasons.

1. To download a custom list of words prepared by the teacher.
2. To store which words a player has already finished. Words are randomly drawn out of the assigned wordlist. However, words that have been selected once have a lower chance to appear again. Also, in order to ensure that newly added content will not be omitted, "fresh" words have a much higher chance of being drawn.
3. To upload data of the children's performance.

A learning application should offer feedback to the students as well as the teachers. The number of completed words for every pupil and the time it took for all players to finish one round is stored.

The next two figures display the connection process. As depicted on figure 2, the players have two choices, either to start a new game (figure 4), or to join an already existing game (figure 5).

Fig. 4. Start Game Screen

Fig. 5. Join Game Screen

Both screens are designed in similar fashion. The first screen appears when a player opens a new game and shows the list of people which have already joined the game. The player who opened the game can decide to start it whenever he/she wishes. The "Join Game Screen" displays a list of open games. The player has to select one game and hit the "Join" button. Then he/she has to wait until the game is launched.

This is the main screen[3] (figure 6) of the app.

The middle of the screen contains the available letters (1), below, resting on the stone wall, is the word-to-guess (2). A hint for the word (3) is displayed in white letters above the middle section. On the borders of the display, next to the railways, are the icons (4) of the teammates located. These icons can be switched (by drag and drop), so that they reflect the sitting position of the players on table. At the bottom left side are two buttons, "Return" and "Help", which are displayed in every screen except the first one. The "Return" button will end the game and take

---

[2] The user-management system will be explained in the following sections

[3] Translation of the screen elements, from top to bottom: textfield (Nr. 3) „At this time of year it is very hot.", yellow railway signs "Send Letter", word-to-guess (Nr. 2) "Summer", button "Back", button "Help"

the player back to the start screen. The help button displays a help message in combination with arrows and images to further explain the gaming mechanism and functionality of the screen.

Fig. 6. Game Screen

The first goal of the game is to fill in the missing letters of the incomplete word, by drag and dropping the letters into the right position. The second part is to help other players finish their words by sending them letters. To do that, the player has to drag the letter on one of the trains (5) or the area around. The icon (4) above the train represents the player the letter is sent to.

When all players have finished their words, a new round is initiated. The game server will semi-randomly draw words out of the downloaded word-pool (with priorities for new / unfinished words) and spread them among the players.

The game ends when there are no more words in the word-pool, or the player who launched the games closes it. If any of the other players leave, the missing letters will be spread among the reaming teammates and the game continues.

Description of the Website for Teachers

The website as shown in figure 7 is a simple interface for teachers to manage wordlists and receive feedback. To login, an account at the user-management system of the TU Graz is required. This is a database of local schools, containing accounts of teachers and pupils and their respective school classes. The system provides an interface for applications.

After a successful login, the teacher has several options. It is possible to create several wordlists, or “wordpools”. Words can be constantly added or deleted from a pool. Afterwards the teacher has to assign a wordpool to a school class. In consequence, pupils who have logged in from the iPad application are able to play with the assigned pool.

In addition, teachers can export or import word-pools as .csv files. Another section of the website displays statistics of the children’s performance, as mentioned before.

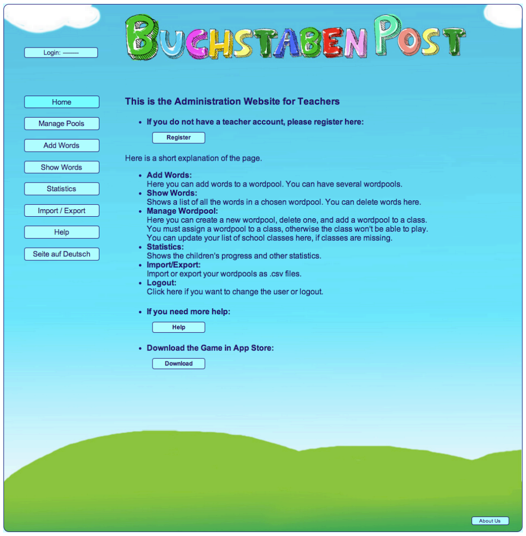


Fig. 7. Web-Interface

Conclusion

The project is focused on cooperation among peers and how to incorporate new technology and gaming into a classroom setting. First field studies rendered practical feedback and it can be stated that this app is a first step towards collaboration through mobile devices.

Certainly, this field of research has much to offer. Regarding the project, several things come to mind:

Further studies have to be performed, especially concerning the learning results of the application and how it compares to conventional learning methods. Considering the social aspect, several questions arise:

Does cooperation during the game affect the social behavior in the classroom? Does it have a positive influence on the children and the class? Does it help them to work together in general, and not only when using the application?

From a technological point of view, the possibilities are numerous. To begin with, the concept of the game could be expanded. As the field study demonstrated, children very much like playing or learning together. Tablets or similar devices make it possible to sit together and communicate in a direct manner. Building on that concept, a number of learning games or applications could be developed that focus on collaborative learning and social interaction. Also, the number of connected devices is not limited in any way. It is possible to connect more or even all devices in a classroom.

The possibilities are numerous and fascinating and with the rapid advancement of mobile technologies, more and more ways to enhance the learning experience will be possible to realize -- not only of school children, but for learners of every kind and age.

References

[1] Chiu, M.M. (2000) 'Group Problem-Solving Process: Social Interactions and Individual Actions', Journal for the Theory of Social Behaviour, pp. 27-49.

[2] Dewey, J. (1916) Democracy and Education. An introduction to the philosophy of education (Reprint 1997), Rockland (NY): Free Press.

[3] Dillenbourg, P. (1999) Collaborative Learning: Cognitive and Computational Approaches. Advances in Learning and Instruction Series, New York, NY: Elsevier Science, Inc.

[4] Downes, S. (2005) E-Learning 2.0, ACM eLearn Magazine, October 2005(10)

[5] Ebner, M (2007) E-Learning 2.0 = e-Learning 1.0 + Web 2.0?, in: The Second International Conference on Availiability, Reliability and Security, ARES 2007, IEEE, S. 1235-1239

[6] Ebner, M., Böckle, M. and Schön, M. (2011) 'Game Based Learning in Secondary Education: Geographical Knowledge of Austria', World Conference on Educational Multimedia, Hypermedia and Telecommunications, 1510-1515.

[7] Ebner, M. and Holzinger, A. (2007) 'Successful implementation of user centered game based learning in higher education: An example from civil engineering', Computers & Education, pp. 873-890.

[8] Ebner, M., Kolbitsch, J. and Stickel, C. (2010) 'iPhone / iPad Human Interface Design', Human-Computer Interaction in Work & Learning, Life & Leisure, pp. 489-492.

[9] Egenfeldt-Nielson, S. (2011) Beyond Edutainment: Exploring the Educational Potential of Computer Games, lulu.com.

[10] Hackfort, D. (2003) Studientext Entwicklungspsychologie 1: Theoretisches Bezugssystem, Funktionsbereiche, Interventionsmögilchkeiten, Vandenhoeck & Ruprecht.

[11] Hannak, C., Pilz, M. and Ebner, M. (2012) 'Fun - A Prerequisite for Learning Games', Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2012, Chesapeake, VA, 1292-1299.

[12] Holzinger, A. (2002) Multimedia Basics. Volume 2: Cognitive Fundamentals of Multimedial Information Systems, New Delhi: Laxmi-Publications, Available in German by Vogel Publishing.

[13] Huber, S. (2012) iPads in the Classroom, Book on Demand GmbH., Norderstedt, Germany

[14] Huber, S. and Ebner, M. (2013) 'iPad Human Interface Guidelines for M--Learning', in Handbook of mobile learning, Z.L. Berge and L.Y. Muilenburg (Eds.).

[15] Hutschinson, H., Druin, A., Bederson, B.B., Reuter, K., Rose, A. and Weeks, A.C. (2005) 'How do I find blue books about dogs? The errors and frustrations of young digital library users', Proceedings of the 11th International Conf. on Human-Computer Interaction (HCII 2005), Mahwah, NJ.

[16] JIM Study (2013) JIM 2013, Jugend, Information, (Multi-)Media – Basisstudie zum Medienumgang 12- bis 19-jähriger in Deutschland. Retrieved from: http://www.mpfs.de/fileadmin/JIM-pdf13/JIMStudie2013.pdf [December 2013]

[17] Johnson, D.W. and Johnson, R.T. (1999) 'Making Cooperative Learning Work', Theory Into Practice, pp. 67-73.

[18] Johnson, D.W. and Johnson, R.T. (2009) 'An Educatirronal Psychology Success Story: Socal Interdependence Theory and Cooperative Learning', Educational Researcher, pp. 365-379.

[19] Johnson, D.W., Johnson, R.T. and Smith, K.A. (1991) Cooperative Learning: Increasing College Faculty Instructional Productivity, The George Washington University: School of Education and Human Development.

[20] Jordan, D.W. and Metais, J. (2006) 'Social skilling through cooperative learning', Educational Research, pp. 3-21.

[21] Kafai, Y.B. (2001) The Educational Potential of Electronic Games: From Games-To-Teach to Games-To-Learn, [Online], Available: HYPERLINK "http://culturalpolicy.uchicago.edu/papers/2001-video-games/kafai.html" [November 2013].

[22] Karlsson, P. and Djabri, F. (2002) 'Analogue Styled User Interfaces: An Exemplified Set of Principles Intended to Improve Aesthetic Qualitites in Use', Proceedings of the 35th Hawaii International Conference on System Sciences.

[23] Kloper, E., Squire, K. and Jenkins, H. (2002) 'Environmental Detectives: PDAs as a Window into a Virtual Simulated World', Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education, 95-98.

[24] Laughlin, P.R., VanderStoep, S.W. and Hollingshead, A.B. (1991) 'Collective versus individual induction: Recognition of truth, rejection of error, and collective information processing', Journal of Personality and Social Psychology, pp. 50-67.

[25] Liang, J.K., Liu, T.C., Wang, H.Y., Chang, B., Deng, Y.C., Yang, J.C., Chou, C.Y., Ko, H.W., Yang, S. and Chan, T.W. (2005) 'A few design perspectives on one-on-one digital classroom environment', Journal of Computer Assisted Learning, pp. 181-189.

[26] Malone, T.W. (1980) 'What makes things fun to learn? Heuristics for designing instructional computer games', Proceedings of the 3rd ACM SIGSMALL Symposium and the 1st SIGPC Symposium on small systems, 162-169.

[27] Mann, B.D., Eidelson, B.M., Fukuchi, S.G., Nissman, S.A., Robertson, S. and Jardins, L. (2002) 'The development of an interactive game-based tool for learning surgical management algorithms via computer', The American Journal of Surgery, pp. 305-308.

[28] Motschnig-Pitrik, R. and Holzinger , A. (2002) 'Student-Centered Teachings Meets New Media: Concept and Case Study', IEEE Journal of Technology & Society, pp. 160-172.

[29] Murphy, P.K., Wilkinson, I.A., Soter, A.O., Hennessey, M.N. and Alexander, J.F. (2009) 'Examining the Effects of Classroom Discussion on Students' Comprehension of Text: A Meta-Analysis', Journal of Educational Psychology, pp. 740-764.

[30] Norman, D. (2004) Emotional Design, New York: Basic Books.

[31] Oblinger, D. (2004) 'The next generation of educational engagement', Journal of Interactive Media in Education, pp. 1-18.

[32] O'Reilly, T. (2007) 'What is Web 2.0?: Design Patterns and Business Models for the Next Generation Software', Communications & Strategies, pp. 17-37.

[33] Papastergiou, M. (2009) 'Digital Game-Based Learning in high school Computer Science eduction: Impact on educational effectiveness and student motivation', Computers & Education, pp. 1-12.

[34] Piaget, J., Inhelder, B. and Inhelder, B. (1969) The psychologie of the child, Basic Books.

[35] Prince, M. (2004) 'Does Active Learning Work? A Review of the Research', Journal of Engineering Education, pp. 223-231.

[36] Preece, J., Sharp, H., & Rogers, Y. (2002) Interaction Design: Beyond Human-Computer Interaction. New York: Wiley

[37] Raines, C. (2002) Managing Millenials, [Online], Available: HYPERLINK "http://www.generationsatwork.com/articles_millenials.php" [November 2013].

[38] Schneiderman, B. (1998) Designing the User Interface - Strategies for Effective Human-Computer Interaction, Addison Wesley.

[39] Solomon, P. (1993) 'Children's information retrieval behavior: A case analysis of an OPAC', Journal of the American Society for Information Science, pp. 245-264.

[40] Zechner, J. and Ebner, M. (2011) 'Playing a Game in Civil Engineering', 14th International Conference on Interactive Collaborative Learning (ICL2011)–11th International Conference Virtual University (vu'11, 417-422.

[41] Zurita, G. and Nussbaum, M. (2004) 'Computer supported collaborative learning using wirelessly interconnected handheld computers', Computers & Education, pp. 289-314.

Category: Paper

GAMEDUCATION: Using Game Mechanics and Dynamics to Enhance Online Learning

Authors: Mohammad AL-Smadi*

Affiliations:

Jordan University of Science and Technology, Irbid, Jordan.

*Correspondence to: maalsmadi9@just.edu.jo

Abstract: Engaging learners long enough to see them through to the end of a course has become one of the most significant problems faced by e-learning developers. The lack of engagement in e-learning can be attributed to three main issues: interaction, challenge and context. Therefore, learning types with high level of interaction and challenge - such as game-based learning – have become widely used. In order to gain the power of games - represented by interaction, motivation, and challenge - e-learning developers started thinking of using game mechanics and dynamics to enhance e-Learning. Gamification of education is still a new trend of research and lacks frameworks and guidelines of how to develop 'gamified' learning tools enabling new forms of engaging learning. This paper reviews theories and research related to learner motivation and engagement. Moreover, it proposes using Gamification in the context of education thus to tackle the lack of learner engagement.

One Sentence Summary: GAMEDUCATION discusses Gamification of e-learning and aims at addressing the challenges of having interactive, challenging, contextualized, and social learning.

Main Text:

1. Introduction

Learner motivation and engagement has become a challenge to e-learning systems. Therefore, learning types with high level of interaction and challenge - such as game-based learning - have become widely used. The use of games technology for learning is not new and online games have been available for more than a decade. According to Kriz [1], interactive-learning environments foster knowledge transfer, skills and abilities improvement in general and social skills in particular. A variety of educational online games have become available to increase learners' motivation, support collaborative learning and games may foster students to gain knowledge [2].

Despite the benefits of game-based learning and serious games [3-8], the wider adoption of serious games in learning is faced by some challenges and barriers such as the large budget a game needs to be developed [9, 6], the lack of games content specifications thus to be reused in other learning scenarios [5], and the integration with the learning management systems to what and how to learn [10]. Therefore, researchers in domain of technology-enhanced learning started investigating the applicability of the so-called Gamification in designing learning tools and systems.

This paper sheds the light on the Gamification research field and gives insights from literature on learners' motivation and engagement. The rest of this paper is organized as follows: Section 2 discusses limitations and challenges for raising learner's motivation and engagement. Section 3 discusses Gamification of education GAMEDUCATION based on theories of social learning and motivation. Nevertheless, it provides a set of findings and recommendations for what does GAMEDUCATION mean and how online learning could be enhanced using Gamification. Section 5 provides conclusions and outlook.

2. Learner Motivation and Engagement in Technology-Enhanced Learning

Motivation is considered as essential factor for effective learning. Motivation for learning has been described as the 'engine' that drives teaching and learning [11]. Moreover, according to Bransford *et al.* [12] motivation affects the time and effort learners plan or consume to learn or to solve problems. Nevertheless, motivation is considered as an important outcome of education [11], thus teaching and learning activities should be carefully designed to promote motivation.

When e-learning first became popular in the early 1990's, cost effectiveness was promoted as its main advantage over traditional methods of instruction. CD-ROMs could be produced cheaply and distributed globally to cater for a high number of users. The introduction of the Internet increased the reach of e-learning systems and many developers rushed to embrace new emerging web technologies. Unfortunately many developers failed to maximize the full potential of such technologies and although they produced systems that appeared attractive, often the content was poor. On the other hand, many researchers argue that students must be meaningfully engaged in the learning resources for effective learning to occur. Engaging learners long enough to see them through to the end of a course has become one of the most significant problems faced by e-learning developers. This lack of engagement in electronic learning content can be attributed to three main issues: interaction, challenge and context (adapted form ALICE[1] project).

– **Interaction**. It is generally agreed that interactivity is a critical factor in the design of e-learning systems. Such interaction directly affects the learner's overall experience and provides motivation to continue in the learning process. Studies researching the effectiveness of e-learning systems highlight the need for immediate feedback, clear short-term goals and better "flow" in moving through the content. The inherent fixed structure of many e-learning systems often fails to provide adequate mechanisms to support interactivity between the user and the system. In many current cases the only interaction available to the learner is to click on the "next" button to step through the material presented.

– **Challenge**. Learners have indicated that unchallenging learning material fails to stimulate them, making the experience unattractive and discouraging progression. As a result, many are reluctant to repeat this experience. Some researchers suggest that effective learning takes place when there is tension between the learner's base knowledge and the gap between the knowledge and skill to be learned. Such tension fosters a sense of curiosity and/or challenge. Motivation can be further enhanced by incorporating clear short-term goals and providing suitable feedback to encourage the learner to continue. Short-term goals help the learner break down a large task into

[1] ALICE Project: www.aliceproject.eu, last visited March 10th 2013.

smaller achievable chunks whilst the feedback gained through interaction helps the learner reflect on the learning process and lets them see the consequences of their actions.

– **Context**. Current e-learning design often fails to situate the learner within the context of their course of study and provide them with a sense of orientation. Students have stressed the importance of being able to appreciate the significance of their current progress in relation to the overall goal of the learning material and how their choices may have affected their progress.

The profile of the modern learner has changed in recent years. With the advent of the so-called "information age" there is an expectation that the workforce will adapt their skills or even change careers to keep in step with technological advancements [13]. This has led to a growing consensus that learning is a lifelong process with many returning to education to retrain. Nevertheless, since the early 1990's, the proliferation of technology means that students have grown up with computers, MP3 players, mobile phones and digital games. This new generation is variously described as "Digital Natives", "Net-geners" and the "Nintendo Generation" [14]. The new learner has so different needs that have to be addressed if e-learning is to be successful. Those needs can be summarized as:

– **Empowerment**. The new learner expects to be in control of their learning experience while in a supportive, collaborative and simulative environment. Thus e-learning systems should promote self-directed learning. Unfortunately, many e-learning systems have a linear structure with a single path through the learning material. While this design is cost-effective, the lack of choice reduces control of the learning experience. Research suggests that having such control is more motivating. A suitable balance is required, however, as self-directed study requires high self-efficacy and vulnerable learners often lack the intrinsic motivation to manage their personal learning experience effectively.

– **Social Identity**. Although current e-learning systems allow learners to move at their own pace they isolate them from their peers participating in the same learning process. This inhibits the learning achieved through social interaction and collaboration, with some learners feeling "lost". Research indicates that a sense of belonging to a social group improves motivation and effective learning overall.

– **Authentic Learning Experience**. Learners expect the material to be linked to prior knowledge and be relevant to their everyday lives and careers. In short, the new learner is seeking an "authentic learning experience". Generally, learners are more engaged when they are participating in activities that they can relate directly to prior knowledge and make connections between what they are learning and the real world.

If such links are missing, learners are less inclined to participate in the learning process and may see it as pointless. For the new generation who are used to customizing their environment there needs to be flexibility in the order and way in which material is studied. Therefore, learning designers have started thinking and looking for tools and ideas to raise learners' engagement and motivation and to provide challenging, contextualized and highly interactive learning tools and objects. Among these ideas is to use the game design thinking in designing online learning.

3. GAMEDUCATION: GAMIFICATION of Technology-Enhanced Learning

Gamification is a new trend of research focusing on using game mechanics and dynamics in non-game contexts to stimulate desired behaviors. Gamification has shown its value in the domain of marketing in particular and other domains such as health, politics, and environment [15]. However, Gamification in education (GAMEDUCATION) aims at redesigning e-learning systems to utilize the benefits of game-based learning and serious games to motivate learners to learn better, further engage them, situate their learning, and to maintain their social identity. However, how to 'gamify' e-learning?

Apart from game-based learning, Gamification of education has little research [16]. The mechanics of the game are the actions, behaviors, and controls that are used to 'gamify' an activity and to stimulate specific emotions on the player, whereas game dynamics are the result of desires and motivations reflecting those emotions (see Table 1).

Table 1. Game mechanics and game dynamics (adapted from [15, 17])

Game Mechanics	**Game Dynamics**	**Game Aesthetics**
Points	Reward	Curiosity
Levels	Status	Satisfaction
Challenges	Achievement	Surprise
Virtual goods and spaces	Self-expression	Trust
Leaderboards	Competition	Envy
Gifts and charity	Altruism	Fun

The definition mentioned above highly depends on the MDA framework for game design [17]. MDA stands for Mechanics, Dynamics and Aesthetics as main elements to consider when it comes to design a game. Reference [18] proposes a more generic definition of Gamification as "the use of game design elements in non-game contexts". However, this definition and the MDA framework hold a design challenge of how to design interactions for game design elements that triggers users' desirable emotional responses in order to stimulate target behaviors. Thus, provides meaningful learning that overcomes the quoted problems and limitations in section 2.

3.1. Raising learner Motivation and Engagement using Gamification

Raising motivation and providing engaging learning is a major concern for TEL designers as discussed in section 2. This section sheds the light on some theories related to motivation and engagement and how those theories are applied to the domain of Gamification.

Among the motivation theories is the 'Flow' theory, - developed by Csikszentmihalyi's in 1979 - is interested in how an intrinsically rewarding experience feels [19]. From his research and interviews, he has concluded that pure intrinsically motivated behaviors involve enjoyment, complete immersion in the activity, detailed focus, feelings of competence, and loss of conception of time. He stated that the enjoyment from the 'flow' experience further motivates the individual to seek additional challenges. This experience or 'flow' can only result from a situation where high challenges are matched with high skills. A skill/challenge imbalance leads to less than ideal emotional states: "*when challenge is higher than skill, anxiety will be experienced; when challenge is low and skills are high, boredom will result; when both skill and challenge are low, apathy will be experienced*."

Most of us have had that "involved" moment happen, when we concentrated our attention so intensely on solving a problem, reading a book, climbing a mountain, on some task, that we lost track of time and when we became aware of our surroundings, few hours or more had passed by as if they were minutes. Such 'flow', according to Csikszentmihalyi [20] is "optimal experience" that leads to happiness and creativity. Flow is the state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will do it even at great cost, for the sheer sake of doing it. If a task is not challenging enough, boredom sets in, while too challenging task leads to anxiety to happen, and both cases should be avoided. As one's skills increase, then the challenge must also increase for one to remain in a state of flow. Because flow is an enjoyable experience, one continues to increase the challenge level, and consequently continues to improve one's skills because doing so is necessary to stay in a flow state. A learning environment in which students are challenged at an appropriate level, which can produce flow, will be more productive.

Another motivation related model is the Fogg Behavior Model (FBM)[2] through which anticipated user behavior is controlled by three main factors: motivation, ability, and triggers. The FBM model argues that for a target behavior to happen, the user must have sufficient motivation, sufficient ability, and effective trigger. According to FBM, a trigger has different names: cue, prompt, call to action, request, and etc. Moreover, the model defines three types of triggers based on combinations of ability and motivation levels as: spark is a trigger that comes when a user has a high ability to do an action and low motivation to do it whereas the facilitator is associated to high motivation and low ability, and a signal trigger has high ability and high motivation in the same time. However, stimulating a desired behavior requires triggering the user to take an action in the right time when s/he has the sufficient ability and motivation.

Motivation to perform an action can be either intrinsic or extrinsic. Intrinsic motivation is usually happening when the behavior itself satisfies users, where extrinsic motivation is often derived by potential gains such as money, rewards, or praise [11]. The research of [21] shows that there is an evidence of the influence of intrinsic motivation on learners' engagement that leads to 'deep' learning through higher level thinking skills and conceptual understanding. Moreover, Crooks [22] highlights the problems associated with extrinsic motivation as it leads to 'shallow' instead of 'deep' learning. The Self-Determination Theory (SDT) focuses on the degree to which an individual's behavior is self-motivated and self-determined. The theory examines the influence of extrinsic motives on the intrinsic ones for achieving target behaviors. For instance, in an analysis study for 128 studies related to motivation evaluation in education led to that mostly extrinsic motives – i.e. rewards – minimized the level of intrinsic motivations [23]. Nicholson [24] argues that the game design elements used to 'gamify' a service should be rewarding themselves without any need for extrinsic motives and rewards. Moreover, Nicholas accommodates the user-centered design theory in designing interactive objects that foster target behavior. Nevertheless, involving users in the creation and the customization of the game design elements used to 'gamify' a system enables them to self-determine which objects matches their interests.

In the same context, Zang [25] builds on the affordance theory – i.e. action properties for an object actor interaction - and argues that Information and Computer Technology (ICT) should be used based on a "motivational affordances". Motivational affordances deal with including

[2] http://www.behaviormodel.org/

only the objects properties that match the users' needs and interests. Deterding [26] goes further and proposes a conceptual model for designing meaningful game elements for Gamification purposes. The model builds on the SDT and implements the motivational affordances theory in order to achieve meaningful Gamification through extending them with situation and context. Deterding also argues that users are more interested and engaged when they interact with elements that match their interest and fit with their context and background.

Focusing on learners' social identity and social style, it's important to relate our discussion to the theories behind social learning. Bandura's social learning theory (SLT) [27] argues that learning occurs due to interaction with others - i.e., in a social context. Behavior, attitudes, and emotional reactions are developed by observing, imitating, and modeling the behavior of other people. In particular, behavior is more likely to be acquired when the result of this behavior is desirable. Accordingly, there are four processes that underline social learning[3]: attention, retention, motor reproduction, and motivation. Therefore, one prerequisite of learning is that attention has to be paid to an object or task. Attention is varied by several factors like individual's characteristics (e.g. sensory capacities or arousal level) or complexity. Retention means that it is necessary to remember for what attention was paid. Reproduction means that the image has to be reproduced, and motivation means that there must be a good reason to imitate the image. Another theory is the social development theory [28] which argues that social interaction plays a fundamental role in the development of cognition. Moreover, Vygotsky argues that the potential for cognitive development depends upon the "zone of proximal development" (ZPD): a level of development attained when learners engage in social behavior. Full development of the ZPD depends upon full social interaction. The range of skill that can be developed with adult guidance or peer collaboration exceeds what can be attained alone.

Social Learning plays major role in defining interactions between objects and avatars in 3D virtual words and serious games. For instance, Smith and Berge [29] investigated the influence of Bandura's SLT in SecondLife[4]. SecondLife is a three-dimensional, virtual world where users are represented by avatars. Smith and Berge suggested that the proposed components of SLT (observing, imitating, and modeling) can also be observed in virtual worlds and that SecondLife is "a great example of social learning theory in action, although there are some components that cannot be satisfied in-world". For instance, it is not possible to observe attitudes and emotional actions in SecondLife. However, cooperation in such learning communities is influenced by the characteristics of its members [30]. Moreover, for emerging a social space, three factors that should be considered: First, there should be *continuity*, meaning that there should be a continuity of contact, members can be recognized, and a historical record of actions. Second, a community should be *populated heterogeneously* with all types of members to ensure liveliness of the community. Third, *clear boundaries* and set of rules are required that can be monitored and sanctioned. Such boundaries facilitate cooperation.

Based on that, how effectively game design elements can be used to 'gamify' non-game contexts in general and TEL in particular. Apparently Gamification goes beyond using game design elements in non-game contexts to more considering how to apply game design elements in non-game contexts while matching the user interest and background and providing situated and challenging elements. Moreover, when it comes to apply Gamification to TEL, alignment with instruction and learning should be considered. Therefore, using ICT in education requires

---

[3] http://www.learning-theories.com
[4] http://secondlife.com

instructional affordances and learning affordances in addition to motivational affordances. This leads to a question of to what extent available/potential Gamification-based learning platforms use the instructional, learning, and motivational affordances.

Researchers in the domain of Gamification are dealing with similar challenges on how to use game design elements in an effective way to provide meaningful Gamification. However, the research focus is limited to motivational aspects. For instance, Nicholson [24] proposes a user-centered theoretical framework for meaningful Gamification through which he is dealing with the user motivation problems. More precisely, the framework tries to solve the problem of negative influence of extrinsic motivation – mainly rewards – on users' intrinsic motivation. The framework leads to define meaningful Gamification as "the integration of user-centered game design elements into non-game contexts". Nicholson argues that involving end users in the creation and customization of the 'gamified' system enables them to select and create meaningful game elements that go in line with their needs and interests.

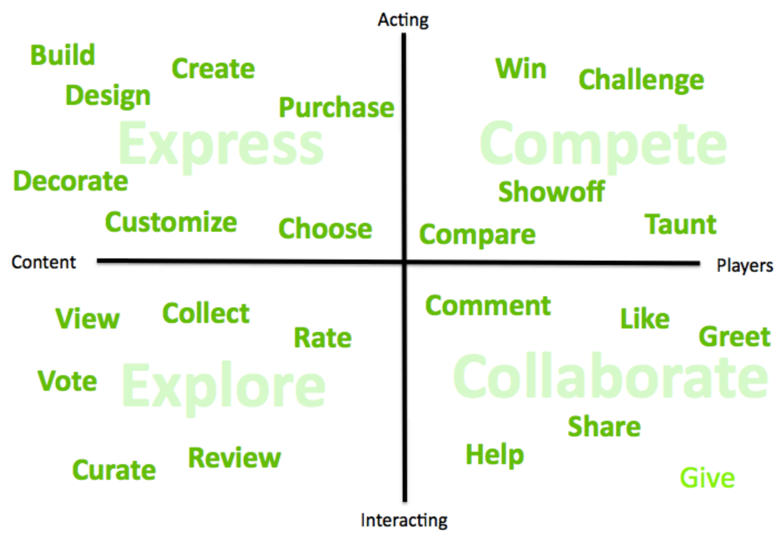


Figure 1. Kim's social engagement verbs (Kim's Blog: http://amyjokim.com).

Kim (2011)[5] discusses how to achieve sustainable engagement in Gamification systems. Kim focuses on social engagement form a viewpoint of a game designer by first knowing who play is and what is their social style. Therefore, Kim has adapted Bartle's MUD player types [31] with more emphasis on social styles of the players into Compete (similar to Bartle's Achiever), Collaborate (similar to Bartle's Socializer), Explore (identical to Bartle's Explorer), and Express (a replacement for Bartle's Killer). Nevertheless, she uses this adaptation to collect social engagement verbs that can be allocated to each on these four types of players' social styles and used to design Gamification systems (see Figure 1). Kim also recommends using the PERMA model in designing the engagement loops of the system. The PERMA Model was developed by Martin Seligman in 2011 and aims at supporting human well-being. PERMA stands for the first letters of the model main components as: Positive Emotion (experiencing positive emotions such as pleasure, curiosity, etc.), Engagement /Flow (moments of consciously involvement in activities), Positive Relationships (enjoyable and supportive interactions with others), Meaning (creating purposeful narrative), and Accomplishment/Achievement (using core values to achieve

[5] Smart Gamification, 2011 , presentation, http://www.slideshare.net/amyjokim

goals). Kim's work and models hold great promises when it comes to maintain learner social identity in learning environments.

3.2. Findings and Recommendations

Applying Gamification to e-education requires alignment to instruction and learning. Moreover, more focus on learners' social identities and social styles should be taken into account. Therefore, in order to provide meaningful Gamification in e-education, GAMEDUCATION proposes in addition to situated motivational affordances [26] instructional affordances, learning affordances, and social affordances. Learning affordances comprise the properties of an object that determine whether and how it can support the activity learning type – e.g. collaborative learning, self-directed learning, etc. Instructional affordances include the properties of an object that determine whether and how it can support the instructional design – i.e. e-learning and m-learning. Finally, social affordances include the properties of an object that determine whether and how it can support in maintaining learners social identity and accommodate their social styles. If TEL designers will be able to design learning objects and thus learning tools in a way that comprise learner needs, interests, and background, moreover to be applied for different learning types and to support different learning approaches then they can contribute to the overcoming of the quoted limitations in TEL and thus provide more engaged learning.

Nowadays no implementation, except for some experiments and attempts limited to single aspects of game elements, is able to offer a complete methodological-technological-industrial solution covering the power of games in designing and providing e-learning. Few examples of learning platforms can be found in which game mechanics and dynamics are used to 'gamify' learning. An example of this approach is the Khan Academy[6], a non-profit project providing free materials and resources with the goal of a better education for all. The project's platform includes several game mechanics like achievement badges and points. It also provides up-to-date statistics of students' progress. Moreover, delivered exercises difficulty and challenge cope with the learner skill level as discussed in the flow theory before. Another example is schooooools.com, a K-6 social learning environment which is enhanced to encompass games elements based on the social Gamification framework [32].

Consequently, findings form literature on building learning environments that are engaging can be summarized as follows:

- Personalized learner profile, by which students are enabled to customize their avatars based on their personal preferences, belong to social space, and be part of groups. Moreover, the profile allows notifications access and maintains privacy.
- Design learning as levels and phases enabling multiple learning paths, repeated experimentation, and problems and exercises. Learning tasks, problems and exercises should be adapted to learner skill level and knowledge state. Once the learner finishes an exercise s/he accumulates points which enable the student to achieve a new level. This achievement should be reflected on his status and updates the rank on the leaderboard which is shared with his learning social space.
- Students should receive rapid feedback cycles which scaffold their learning progress and updates their progression bars in the learning social space. Social recognition and rewards may motivate students, engage them, and improve their social and learning skills.

[6] http://www.khanacademy.org

- Complex learning tasks should be broken into simple tasks, the tasks difficulty should be increased to cope with the learner skill level thus to improve learner expectations on completing the task successfully. Moreover, the learning task should be designed to allow different paths to success. This enables the learner to define personal goals and objectives and select and tries several paths to reach the final goal and achieve her/his personal learning goals. Once the learner accomplishes a complex learning task the system - could be teacher, peers - provides bonuses.
- The system should enable social spaces and stimulates desired behavior and social interaction - like supporting peers, peer-review, providing comments, discussion posts, organizing activity, etc. - by offering badges.
- The system should offer the possibility to exchange points and badges with virtual goods or even receive tickets, trips, or registration discounts - could be tuition fees discount. This will stimulate desired behaviors and more engage learners.
- Learners should be empowered to play different roles and participate in the design of the learning activity as well as assessment forms.
- Learning content and tools should be highly interactive and provides challenging learning tasks that adapts to the learner skill and knowledge state.

4. Conclusion and Outlook

Gamification is a new trend of research which refers to the use of game mechanics and dynamics in non-game contexts to stimulate desired behaviors [16]. Gamification of education (GAMEDUCATION) aims at redesigning e-learning systems to utilize the benefits game design elements in motivating learners to learn better, further engage them, situate their learning, and to maintain their social identity. However, applying Gamification to e-education goes beyond using game design elements in e-education and requires alignment to instruction and learning. Moreover, more focus on learner's social identities and social styles should be taken. Therefore, in order to provide meaningful Gamification in e-education, GAMEDUCATION proposes in addition to situated motivational affordances [26] instructional affordances, learning affordances, and social affordances. More precisely, GAMEDUCATION deal with including only the learning objects properties that match the users' needs and interests, situate their learning, and maintain their social identity.

References and Notes:

1. W. C. Kriz, Creating Effective Learning Environments and Learning Organizations through Gaming and Simulation Design, *Simulation and Gaming*. **34**, 4, 495-511, (2003).
2. C. Gütl, in *Francesca Pozzi and Donatella Persico (Eds.)* (IGI Global, 2011), 278-299, (2010).
3. M. Prensky, *Digital-game based learning*. (McGraw-Hill, 2001).
4. J. P. Gee, *What video games have to teach US about learning and literacy*. (Palgrave Macmillan, 2003).
5. S. De Freitas, *Learning in immersive worlds: A review of game-based learning*. (JISC e-Learning Programme, 2006).
6. R. Van Eck, Digital game based learning: It's not just the digital native who are restless. *Educause Review*. **41**, 16–30, (2006).

7. E. Klopfer, S. Osterweil, K. Salen, *Moving learning games forward: obstacles, opportunities and openness, the education arcade*. (Massachusetts Institute of Technology, 2009).
8. J. McGonigal, *Reality is broken: Why games make US better and how they can change the world*. (Penguin Books, 2011).
9. L. Johnson, R. Smith, H. Willis, A. Levine, K. Haywood, *The 2011 Horizon Report K-12 Edition*. (Austin, Texas: The New Media Consortium, 2011).
10. D., Burgos, P. Moreno-Ger, J. L. Sierra, B. Fernández-Manjón, M., Specht, R. Koper, Building adaptive game-based learning resources: The marriage of IMS learning design and <e-Adventure>. *Simulation & Gaming*, **39**, 414-431, (2008).
11. W. Harlen,. In *J. Gardner (Ed.)*. (London: Sage Publications, 2006) 61-80.
12. J. D. Bransford, A. L. Brown, R. R. Cocking, *How people learn*. (Washington D.C.: National Academy Press, 2004).
13. F. J. Dochy, L. McDowell, Introduction. Assessment as a tool for learning. *Studies in Educational Evaluation*, **23**, 279-298, (1997).
14. M. Prensky, Digital Natives, Digital Immigrants. *In On the Horizon*. **9**(5) NCB University Press. (2001)
15. Bunchball, Inc. (2010). Gamification 101: An introduction to the use of game dynamics to influence behavior.
16. J. Lee, J. Hammer, Gamification in education: What, how, why bother? Academic Exchange Quarterly, **15**(2), (2011).
17. R. Hunicke, M. LeBlanc, R. Zubek, Proc. AAAI workshop on Challenges in Game, AAAI Press (2004).
18. S. Deterding, D. Dixon, R. Khaled, L. Nacke, Proceedings from MindTrek '11. Tampere, Finland: ACM, (2011).
19. M. Csikszentmihalyi, *Optimal Experience*. (New York: Cambridge University Press, 1988).
20. M. Csikszentmihalyi, *Flow:* The *Psychology of Optimal Experience.* (New York: Harper and Row, 1990).
21. T. Kellaghan, G. F. Madaus, A. Raczek, *The Use of External Examinations to Improve Student Motivation.* (Washington, DC:AERA, 1996).
22. T.J. Crooks, The impact of classroom evaluation practices on students, *Review of Educational Research*. **58**, 4, 438-481, (1988).
23. E. Deci, R. Koestner, R. Ryan, Extrinsic rewards and intrinsic motivations in education: Reconsidered once again. *Review of Educational Research*. **71**(1). 1-27, (2001).
24. S. Nicholson, Paper Presented at Games+Learning+Society 8.0, Madison, WI, (2012).
25. P. Zhang, Motivational affordances: Reasons for ICT design and use. *Communications of the ACM*. **51**, 11, 145-147, (2008).
26. S. Deterding, Presented at Gamification: Using Game Design Elements in Non-Gaming Contexts, a workshop at CHI 2011.
27. A. Bandura, *Social learning theory*. (New York: General Learning Press, 1977).
28. L. S. Vygotsky, *Mind in Society: The development of higher order psychological processes*. (Cambridge and London: Harvard University Press, 1978).
29. M. Smith, Z. L. Berge, Social learning theory in Second Life. *Journal of Online Learning and Teaching,* **5** (2), (2009)
30. Kester, et al. Proc. of IADIS International Conference Web Based Communities, 80-87, (2006).
31. R. Bartle, Hearts, Clubs, Diamonds, Spades: Players Who Suit MUDs. *Journal of MUD Research* **1**, 1 (1996).
32. J. Simões *et al.* A social gamification framework for a K-6 learning platform. *Computers in Human Behavior* (2012), http://dx.doi.org/10.1016/j.chb.2012.06.007.

Category: Presentation

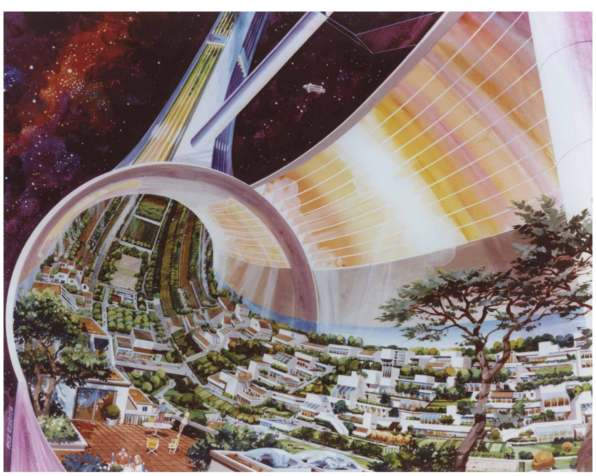
Title: Architecture (Building Design) as a significant unifying educational component in Immersive Education

Author/Presenter: Terry A. Beaubois, M.Architecture, University of Michigan

*Correspondence to: Terry Beaubois, beaubois@stanford.edu where he is currently a Lecturer in the College of Engineering, Architecture Design Program at Stanford University, Palo Alto, California US.

Abstract: Architecture is the design of buildings and requires the integration of science, technology, engineering, art, and math. Architecture is a significant, unifying, educational component in Immersive Education, from pre-school to Continuing Education. In addition, educational areas not directly associated with Architecture, such as History, Archaeology, Material Sciences, and Trade / Finance, can benefit from engaging students in the creation of and use of immersive architectural environments. From our first building blocks in Kindergarten to advanced visualization and information management systems in current practice, Architecture engages us with people, things, spaces, buildings and the world around us and encourages the use of imagination. As technology continues to evolve and is easier to use, the relationship between Immersive Education and Architecture will become even stronger. In research, teaching, and professional applications, Architecture benefits from and contributes to, developments in the technologies associated with Immersive Education. In this presentation, current and ongoing examples of research-to-education-to-application will be included - from the earliest NASA Space Station design experiments with Virtual Reality technology, to current announcements in the developments in the use of Immersive Education in regional education programs. Examples of the benefits of communication between research-education-and applications will be discussed.

One Sentence Summary: Applying advancing computer and internet technologies to research, education, and practice of architecture (building design).



Space Station Concept Design illustration by Rick Guidace/NASA

Main Text

Introduction

The meaning and scope of the concept of "Immersive Education" continues to evolve and grow. So does the research, education, and application of technology in the areas related to Immersive Education. This presentation will show specific examples of research projects and how the communication between research, education, and application of new research, specifically in the area of Architecture and Immersive Education, is integral and beneficial to the process. Specific examples will include work that is based in the Silicon Valley area of Northern California, but also indicate the regional, national, and international aspects of this research.

Terry Beaubois's first research efforts in Immersive Education were as a consultant to the NASA Space program beginning in 1978 with NASA-Ames Research Center. When it was realized that, to successfully design a space station, NASA's "vehicle-design" focus (rockets) needed to be supplemented by more spatial or "environment-design" knowledge, NASA reached out to architects to become involved. At that same time, NASA was undertaking research in the application of advancing computer technology to it's own research in aerodynamics, prototyping, conceptualizing.

Some of the earliest technology intended for "Telepresence" - NASA's term for Virtual Reality at the time - where an astronaut could stay inside the space station, wearing goggles and remotely operate a robot outside the station to do a repair, was involved. Eventually, because the Space Station didn't exist, simulator technology was used to create a Virtual Space Station and virtual robots and early VR began. Immersive Education at it's very beginning. Also, NASA needed to disseminate information, "educate" teams, and learn the capabilities of the new technology, as it continued to evolve. Terry Beaubois helped form and became Director of the NASA/AIA joint Advanced Technology Application Committee and received a grant from NASA Headquarters to research and identify opportunities for transferring aerospace technology into other architecture-related industries. This work was undertaken while Terry was a research associate at UC Berkeley, College of Environmental Design in 1985-86.

This began Terry's career-long involvement with connecting advanced research, education, and application in areas related to Architecture. Today using the same principles, Terry Beaubois is involved with Silicon Valley technology; with Stanford University, College of Engineering, Architecture Design Program; and working on research, education, and application of the current technologies to Architecture and Immersive Education.

Scope of current work:

An ecoSMART House 1.0 project was done while Terry Beaubois was director of the Montana State University, College of Arts & Architecture, Creative Research Lab (2005-2013). A study is currently beginning on doing an ecoSMART 2.0 House upgrade project at the Montana Home. Current 2.0 research work includes a study of the incorporation of MEM sensors and beacon technology into the house and including more advanced water quantity use and water quality monitoring.

ecoSMART 2.0 functions could include health monitoring, way-finding, and building diagnosis information. The Center for Outpatient Rehabilitation Medicine at Stanford is currently researching from their perspective what information would be of value and how much can be collected with wearables. Our architectural expertise will further explore how buildings could supplement and compliment this with additional information about the patient's outpatient recovery.

In addition, we are researching how buildings can be designed to have a desired, opt-in, functional ecosystem of communication within the building — around the home, automobiles-to-home, wearables-to-home, smartFurniture, and we will be including non-residential buildings such as healthcare facilities and hotels, as the study progresses.

Plans to expand beyond a single building and begin to consider the scalability to communities (of homes or buildings) and how data, that is or could be beneficial to campuses (research, educational and corporate) and communities could best be collected. The monitoring of energy use and water use can be very helpful information for communities desiring to know and reduce their community's overuse.

Continuing the work that the iED has done with the US National Park Service (to be presented at this conference) about the Santa Fe Trail, our work will separately continue the concept of "Historic Trails" and feature the Gold Rush Trail in California. The Gold Rush Trail connected San Francisco and the California Gold Country. This Immersive Education endeavor will engage school children throughout the Greater San Francisco Bay Area in learning about a foundational event in the growth in San Francisco and gaining an appreciation for the quality of life that is contributed by the National Park System in the balance of Natural and Built Environment in the Greater San Francisco Bay Area.

Montana ecoSMART House 1.0 Project

Conclusions:
Terry Beaubois encourages interested conference attendees, through the EiED Research Committee, to consider the role that Immersive Architectural Educational Environments can play in each of our work, as iED plans for the 2015 Conference in the Silicon Valley / San Francisco Area.

Category: Poster

Title: Engage students using a serious game in an Open Sim: a path on volcanism in Phlegraean fields

Authors: Annalisa Boniello[1,†], Eleonora Paris[1,‡]

Affiliations:

[1]School of Science and Technology, Geology Division, University of Camerino, Via Gentile III da Varano, 62032 Camerino, Italy

†annalisa.boniello@unicam.it

‡Eleonora.paris@unicam.it

Abstract: Virtual worlds in education today represent an innovative strategy and an educational opportunity to learn in a socially-interactive learning community and in an immersive environment. It is possible to recreate in 3D environments parts of a volcanic area, interactive tours on earthquakes and natural disasters, where students can immerse themselves with an avatar and learn with an immersive training what types of volcanoes exist, such events may occur and what are the correct behavior to adopt in case of disaster. A virtual environment can then simulate what measures are necessary to mitigate the risk and respond appropriately to these events.

To experience this approach, this research introduces digital contents on Disaster Management in a volcanic environment, Phlegraean Fields, using a MUVE (Multi User Virtual Environment) an Open Sim (1) called Unicamearth, addressed to students of various ages. It has online access, where, through a role play, learners cross various steps based on inquiry based Science education (IBSE).

Category: Poster

Title: Project Course-Group Towards Product Development

Authors: Márta Turcsányi-Szabó[1,†,*]

Affiliations:

[1]ELTE University, Faculty of Informatics, T@T lab, HUNGARY.

*Correspondence to: tszmarta@inf.elte.hu

†1117 Budapest Pázmány Péter Sétány 1C, HUNGARY

Abstract: The Faculty of Informatics not only has to teach Computer Science in theory, but also has to use it in order to show its value in suitable applications that not only facilitate better learning processes, but also motivate learning and elevates its significance within the world of entertainment. Besides, students have to be aware of emerging technologies, become active and reliable members of live interdisciplinary projects involving industry, and trigger innovation using the synthesis of one's own profile extended with mastered knowledge. Ideally, we should find 21st century methods to engage the Net generation in learning science, enjoy and think creatively and become a conscious entrepreneur in their own field.
The Interactive Media Development course-group is one of the courses that embeds interdisciplinary projects involving museums and bridging institutions producing products in co-operation and is also offered for international studies within EIT ICT labs Masters' program. Students can register for the course-group under different specific courses.
The course-group web site (http://intmedia.elte.hu/) contains several themes to choose from: Introduction, Data visualization, Interaction design, User interfaces, Multimedia design, Digital narratives, Learning media, Museum technologies, Game design, Bewildering codes, Virtual worlds, Mobile technologies. Requirements include: basic understanding of three chosen themes (which should be mastered self-paced depending on interest and specifics of course requirements the student registered for), user level awareness of all projects produced during the semester and a personalized developer role within one of the actual projects in collaboration this other disciplines to produce interactive media for learning purposes. The poster explains how different technologies serve the developer learning community of practice and how the products are piped back into the immersive learning process. The course-group just won a Tempus prize for showing good practice in STEM education on higher education level.

Category: Poster

Title: Memory and Immersive Applications. The use of MAR to Preserve Local Tangible and Intangible Heritage

Authors: Dragoş Gheorghiu[1,]†, Livia Ştefan[2,]‡

Affiliations:

[1]Doctoral School, National University of Arts, 19 Budişteanu Str., Bucharest, Romania.

[1]Department of Computing Applications, Institute for Computers, Calea Floreasca 167, Bucharest, Romania.

†gheorghiu_dragos@yahoo.com

‡livia.stefan@itc.ro

Abstract: To protect and rescue the local heritage a degree of awareness and involvement of the local communities is required, as stressed by the La Valetta convention. We present an example of this cultural strategy applied in a European traditional community, i.e. in the village of Vădastra, in Southern Romania, near the Danube River, using immersive environments, within the research project Time Maps. In this case we have implemented and experimented educational applications based on Mobile Augmented Reality (MAR), first to reconstruct the specific layers of dwelling of the site, i.e. the Chalcolithic and Iron Age layers, and then to reveal the areas requiring protection in an intuitive and immersive manner. The educational applications combine two MAR paradigms in a continuum with the purpose of creating immersive environments for enhancing learning in situated contexts: a location-based MAR and a marker based image recognition MAR. Consequently the augmented information is presented to the user both by searching in the historical context and by identification of representative visual markers. The most important archaeological Points-of-Interest (POIs) where augmented with explanatory texts, 2D images and 3D architectural reconstructions, displayed such as to suggest an archaeological stratigraphy, i.e. overlapped layers of occupation, and produce a more immersive effect. On the other hand, to define the visual context, the prehistoric settlement and the Roman villa rustica were marked with images representing textures specific to these historical periods: a Roman ceramic bricks, and a prehistoric mixture of clay and straws. Scanned by video camera, these images trigger other kind of augmentations: 3D virtual tours of a prehistoric house or of the Roman villa rustica, and a series of video films, displaying the technologies underlying the reconstructed objects.

Category: Poster

Title: EUROVERSITY - a European network to promote the usage of virtual environments for learning

Authors: Gerhilde Meissl-Egghart[1,]†, Klaus Hammermüller[1,]‡

Affiliations:

[1] talkademy.

†gerhilde@talkademy.org

‡klaus@talkademy.org

Abstract: EUROVERSITY is a three-year project co-funded by the EU Lifelong Learning Program, Key Activity 3 ICT. Euroversity is a network of 18 partner from 10 European countries and a third country partner from Israel. This network is made up of a collection of organisations that have had significant experience of the use of 2D/3D virtual worlds in learning and teaching contexts (in European projects such as AVALON, AVATAR, START, LANCELOT and NIFLAR), a smaller number of partners with limited experience who wish to apply the experiences of the network to the design and construction of new courses within virtual worlds in their own contexts, and other institutions who have no direct experience of virtual world education but who have a specific interest in education, media, and in the transformation of knowledge. The aim of the project is to engage enough of a critical mass of users of online 2D/3D virtual environments, so as to generate more users by transferring their newly acquired knowledge to their specific contexts. The duration of the network is such that there will be the possibility to initiate, train and follow-up new end users during the project. The community resource created by the project outlining the good practice framework and the experiential video data bank will provide content which will outlive the project's duration. The website and project content will remain live for a minimum of five years following project completion.

iED

Category: Poster

Title: The Depo-Deck: How blending smart flash-cards with a mobile application can deliver higher level learning of complex geological concepts in oil & gas industry corporate training

Authors: Amir Bar[1,]†, Jeffrey Yarus[1,]‡

Affiliations:

[1]Halliburton.

†amirbar@mac.com

‡jyarus@lgc.com

Abstract: The Depo-Deck is a set of 19 game cards (3.5"x2.5") which are designed to deliver printed information as well as provide access to an online mobile module via QR codes. The Deck's learning objective is to teach geologists how to parameterize rules used to characterize oil and gas deposits in modeling software, more effectively and efficiently than traditional classroom setting.. The deck offers 19 cards that include an introduction, printed and online reference information and two cloud-based mobile assessments (quizzes). The Deck contains two types of cards, a primary set of 16 cards designed to train the student on the methodology and provide a basic assessment, and a secondary card designed to assess conceptual understanding. To date, this product has been tested in three different environments: a professional conference, corporate training, and in a graduate petroleum engineering course. The presented data includes 102 cases. In all environments the product was successful in achieving the major objectives. The assessments results showed a learning curve which demonstrates students were able to master the concepts in significantly less time. . The use of smart flashcards coupled with a mobile application reduced the total learning experience from 3 hours to 30 minutes, an efficiency improvement of more than 80%. In addition, students engaged in the activity enthusiastically, enhancing the full learning experience. This poster demonstrates the products and content we developed including the deck of cards, mobile modules, and cloud-based applications and explain the best practices around the development process. The poster also includes the relevant QR codes so that viewers can engage in live interaction with the online modules. Several of the physical Depo-Decks will be available as well for the full hands-on experience. Those who chose to engage in a live hands-on experience during the poster session will be able to receive immediate feedback of their results via their own mobile device.

Category: Poster

Title: Measuring Collaborative Virtual Presence and its Link to Team Performance

Authors: Anne Massey[1,]†, Mitzi Montoya[2,]‡, Anne Stright[1,]*

Affiliations:

[1]Indiana University, United States.

[2]United States Arizona State University, United States.

†amassey@indiana.edu

‡mitzi.montoya@asu.edu

*astright@indiana.edu

Abstract: Business enterprises are beginning to explore the application of desktop collaborative virtual environments (CVEs) to support goal-oriented, purposeful distributed teamwork. In general, a CVE may be defined as a computer simulated 3D space where users, via digital representations known as avatars, can interact with one another and digital objects. In essence, by providing both an accessible and persistent virtual visual workspace, CVEs present an entirely new way for distributed collaborators to interact and work.
A metric of the quality of a CVE is the degree to which it creates a sense of presence in the environment. It is considered to be the essence of any experience in a CVE. Presence is often described as the feeling of "being there" in the virtual place rather than in the physical space where one's body is really located. For collaborative work, the notion of "being there" in a CVE is enhanced by the possibility of acting or "doing there". CVE designers consider presence to be a desirable attribute and self-evident goal. Despite its presumed importance, there has been very limited empirical evidence regarding the link between presence and performance, particularly in the context of collaborative teamwork. This link is particularly important in a business context because it contributes to the determination of return on investment (financial and human resources) in CVEs to support virtual teamwork. Establishing the link between presence and performance is complicated by the challenge of how to measure collaborative presence. Without a valid measure, informed decision-making is hindered. Thus, our objectives include the: (1) development and validation of a multiple-item, multi-dimensional scale to measure the 'collaborative virtual presence' (CVP); and (2) the assessment of the relationship between CVP and performance in a CVE. In our poster we will share the results of a series of four laboratory experiments in a 2x2 design to address these research objectives and a set of hypotheses. The two experimental conditions involve manipulation of (1) task requirements in terms of the degree of CVE navigation needed (Low/High), (2) induced breaks-in-presence (BIP) stimuli events (present/absent).

Category: Poster

Title: Rhizomatic Growth of an Immersive Learning Design

Authors: Juan Rodriguez[1,*]

Affiliations:

[1] University of Toronto, Canada.

*jc.rodriguez@mail.utoronto.ca

Abstract: This poster explores the metaphor of the "rhizome" from a post-modern perspective based on the interaction between members of a working group, through the design and implementation of immersive learning strategies. The multidisciplinary group was responsible for the design of four online courses, based on a face-to-face course outlines. Critical points of decision making, transformation, and growth are represented as salient moments over this six month project. Immersive learning strategies were proposed, designed, analyzed, and accepted, modified or rejected. As opposed to vertical growth and linear sequence, rhizomatic movements between crucial points are considered expressions of growth of immersive strategies due to the subject positions adopted by participants in the process. Immersive learning activities emerged from tensions and conflicts between subject positions described.

Category: Long Paper

UniCoMP - An Approach Towards Flexibility, Versatility and Liberty of Action on Stage

Authors: Oliver Hödl[1*], Geraldine Fitzpatrick[1]

Affiliations:

[1] Vienna University of Technology, Human Computer Interaction Group, Argentinierstraße 8/187, 1040 Wien, Austria

* oliver@igw.tuwien.ac.at

Abstract: Musicians have been exploring new ways of making music using different custom-built and modified instruments and additional devices during performances. However, these can increase the learning effort and reduce flexibility for the performer on stage. In this paper we present "UniCoMP" (Universal Control for Musical Performances), a wireless, easy-to-use and versatile system using off-the-shelf hardware and software to more flexibly play instruments and control devices during a performance. We describe the design of UniCoMP and the results of a pilot video-based evaluation to test its use during a live concert. We found that UniCoMP increased flexibility regarding playing instruments and controlling sound effects on stage and at the same time offered the artist freedom of movement for dramaturgic purposes. We also identified deficiencies in the user interface, leading to suggestions for future improvements and for additional evaluation.

One Sentence Summary: A study of using a smart phone as universal remote controller for musical performances.

1. Introduction

Musicians, and of particular concern here, guitarists, are increasingly engaged with multiple actions and devices in order to create entertaining stage performances. Playing an electronic guitar is usually done with both hands. Additionally musicians often use their feet to control devices on the floor for sound modulation. By stepping on different switches the guitarist activates or deactivates certain effects or chooses presets in multi-functional effect devices. While this opens a wide range of possibilities to change the sound in real-time during a performance, it also forces the guitarist to stay close to the effect device for operating purposes or return to it frequently after moving around on stage, limiting dramaturgical possibilities. Furthermore functionality is restricted to choosing among presets and not changing single parameters of effects.

There have been many attempts during the last two decades to offer more flexibility and better usability when using effects while playing electric guitar. For example, Engum attached a USB keypad with digits to a guitar to enable change presets directly from the instrument [1]. Furthermore he added an off-the-shelf touch pad underneath the pick-ups and strings to enable modulation of the sound while playing directly at the guitar. A similar approach by integrating a touch pad in a guitar was developed earlier by the instrument maker Manson [2] for the guitarist of the band Muse [3]. Lähdeoja uses the data of three sensors integrated in his augmented electric guitar for dynamic control of signal processing [4]. Reboursière et al. developed another augmented guitar considering all parts of the signal chain from audio analysis to gestural control to audio synthesis [5]. Instruments other than guitars have also been augmented [6] and new instruments for playing music and controlling sound have been developed [7].

However, all these approaches involve either custom-built instruments or require that instruments be re-designed or modified with a more or less high amount of technological knowledge and effort for realization. Even for musicians it is problematic and time-consuming to readjust themselves after modification or to learn new instruments, as elaborated by Dobrian and Koppelman within the context of new interfaces for musical expression [8].

In this paper, we explore a different approach to 'live' effects modification that allows musicians to still use their usual instruments and allows them to move around on stage as they like. We report on a system called "UniCoMP" (Universal Control for Musical Performances), providing a guitarist with an off- the-shelf smart phone and laptop for controlling and modulating the sound of the guitar and remotely playing additional instruments like a synthesizer. As we use everyday devices UniCoMP is easy to afford and to assemble. Within this context we are questioning if we can achieve (1) flexibility regarding control of sound effects, (2) freedom of action on stage and finally (3) versatility of an easy-to-use system. To answer this, we use an auto-ethnographic approach [9, 10] conducted by the first author who is also a performing artist. This gave us the chance to perform a pilot evaluation of UniCoMP during an authentic public concert. The findings indicated that a conventional performance could be enriched by providing a tool that enhances the playing of the original instrument and adds new possibilities to play it and additional instruments.

The main contributions of this paper are: presenting UniCoMP as a wire- less, easy-to-use and versatile system for musical performances; and identifying directions for its further development based on experience in use.

We proceed with a usage scenario and the technical description, then describe the in-situ study at a live concert and finally discuss the evaluation.

2. Technical Design of UniCoMP

UniCoMP was designed against a scenario of use where the guitarist is playing a traditional electric guitar and a stage piano throughout a performance. The sound from the guitar is processed through an effect floor board and the sound for the stage piano is created through a software synthesizer on a laptop. The guitarist also wears a wrist mounted smart phone through which he can control both the sound of the guitar and the synthesizer.

To implement a UniCoMP prototype, we used common off-the-shelf devices and software for the purpose of versatility and minimization of efforts and costs. A description of all devices and the signal flow is presented in Fig. 1 and described in the following.

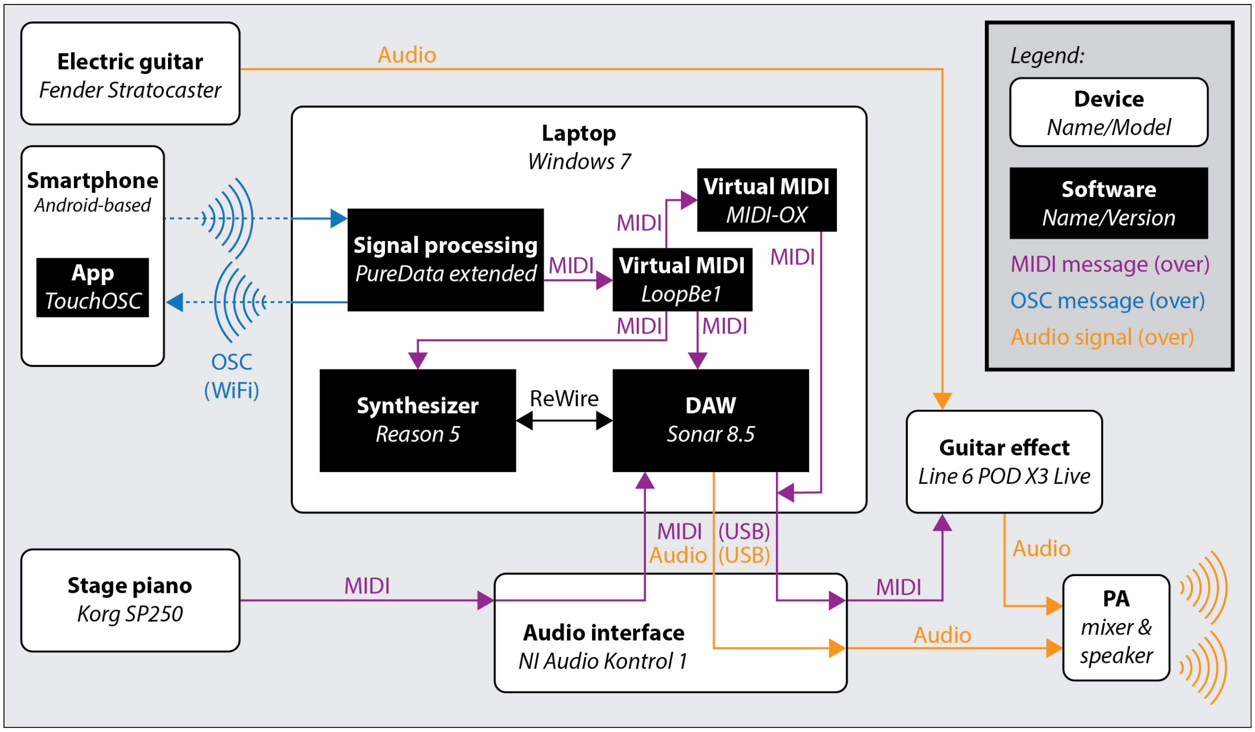


Figure 1. Signal flow within UniCoMP.

2.1 Instruments and Interfaces

The smart phone is designed to be mounted on the wrist of the right hand, comparable with a wristwatch, so as not to interfere with the guitar playing while also allowing easy access to the device. For our prototype, we simply used heavy-duty tape in combination with a hook and loop fastener.

The guitar itself is not modified at all. Thus, the performer can choose to use any guitar without additional configuration or effort. A common guitar effect floor board manages the sound modulation of the guitar. The stage piano is played as usual and its sound is synthesized by the laptop. Finally a simple off-the-shelf audio interface for the laptop distributes all signals from and to external audio devices.

2.2 Signal and Sound Processing

We used an Android-based smart phone which hosts the application "TouchOSC"[1] and sends OSC messages over WiFi from the smart phone directly to the laptop. All OSC messages - precisely signals of sliders, buttons and accelerometer data - that are received by the laptop are first handled by PureData (pd) [11] which then creates MIDI messages for further signal processing. Depending on the input, pd distributes them through virtual MIDI drivers to three different targets for controlling and generating sound: (1) a digital audio work- station (DAW),

---

[1] https://play.google.com/store/apps/details?id=net.hexler.touchosc_a [last accessed 10th October 2014]

(2) a software synthesizer and (3) directly through the audio interface to the guitar effect floor board.

The digital audio workstation (Sonar 8.5)[2] does the central sound control. The DAW has a built-in sequencer that has three main tasks in every song: (1) giving the beat to the musicians' in-ear monitoring, (2) playing pre-recorded samples, and (3) sending pre-defined MIDI messages to the guitar effect floor board. Furthermore the DAW uses the software synthesizer as a virtual instrument over the ReWire protocol to process MIDI inputs from the piano.

The software synthesizer (Reason 5)[3] generally provides sound synthesis to the DAW and apart from that listens to MIDI messages sent from TouchOSC through pd for playing and controlling sounds directly from the smart phone.

The guitar effect floor board (POD X3 Live)[4] is either controlled by foot as usual to change presets or additionally through TouchOSC which enables the control of various parameters directly at the device through MIDI messages.

2.3 Functionality

TouchOSC comes with several predefined interface layouts and easy customization of layouts. The mapping of the interface elements to parameters of the guitar effect device and the synthesizer is configurable in pd. Thus, UniCoMP is very flexible and adaptable.

According to the requirements of the songs that were going to be played in our particular performance, we chose a pre-defined layout with four toggle buttons and five sliders. This is shown in a screenshot of TouchOSC in Fig. 2, along with a description of the functionality of the buttons and sliders. The details of all functions and effects are beyond the scope of this paper and also not necessary to understand the general idea of UniCoMP. The interface can be customized easily according to the requirements of the songs for any particular performance. A more generic interface can also be created if needed.

To summarize UniCoMP can be used in various ways during a performance: (1) start and stop the DAW's sequencer for the playback of additional sounds and the metronome, (2) manipulate the software synthesizer's range wheel as the stage piano has none built-in, (3) use it as a standalone instrument playing a tone of the synthesizer and modify it by moving the smart phone accelerometer on the hand, (4) manipulate guitar effects remotely using the accelerometer while playing and (5) manipulate guitar effects remotely with sliders and buttons during a short break or while letting a tone fade away.

---

[2] http://www.cakewalk.com/products/sonar/ [last accessed 10th October 2014]
[3] https://www.propellerheads.se/products/reason/ [last accessed 10th October 2014]
[4] http://line6.com/legacy/podx3live [last accessed 10th October 2014]

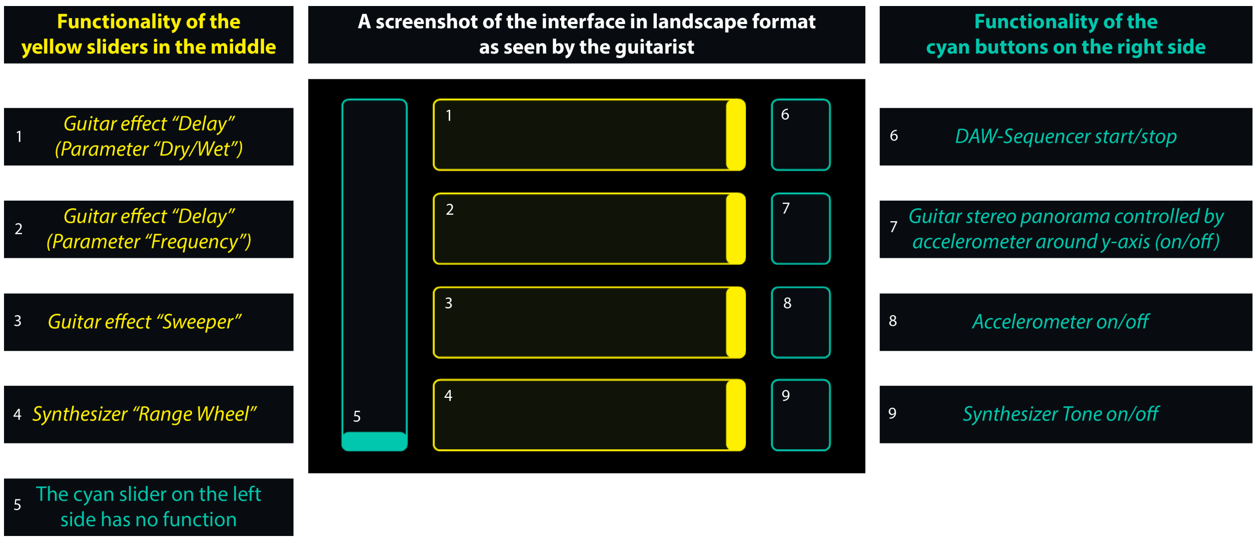


Figure 2. A screenshot of the UniCoMP TouchOSC interface as seen by the guitarist, with the description of sliders and buttons.

3 In-situ Study

We conducted an in-situ pilot study to evaluate UniCoMP during a public live concert of the artist (first author). A schematic overview of the venue, including the six-meter wide stage, is shown in Fig. 3. Every device in this overview has a corresponding device in Fig. 1.

On stage we have various stationary points of interest: (1) the drummer at the back of the stage in the middle, (2) the stage piano for playing the synthesizer and the laptop on the right side, (3) the guitar effect floor board on the left side, and (4) a scaffold for live-painting and show effects nearby. The musician, with the guitar and the smart phone on his right wrist, is able to move around on stage freely. This can happen quite frequently as part of the show when the guitarist moves between the three microphones, paints at the scaffold, controls the guitar effect floor board and plays the piano.

3.1 Methods

For the pilot study, we chose an auto-ethnographic approach, where the first author used the system during his live concert. The performance was video- recorded for later self-reflective evaluation. The main reason for choosing an auto-ethnographic approach [9] is the system itself. Although easy to assemble and handle it is still an early prototype and we wanted to test its stability in a live setting before giving it to other artists to use. Moreover the focus was on exploring UniCoMP's suitability and functionality during a performance rather than exploring particular experiences of different artists or of the audience (this needs more objectivity and will be subject to later studies).

While the system was used for the whole concert, for the evaluation we focused on one song on which to conduct an in-depth video analysis, similar to an approach by Reeves when studying interaction in public settings [12]. For this purpose the whole stage was video-recorded during the performance. The choice of the particular song was well-considered to test different types of uses of UniCoMP while the artist moved around stage. The song starts with a pre-recorded spoken voice played by the sequencer running on the laptop while the guitarist paints at the scaffold. During the following major parts of the song until the end, the guitar and the synthesizer are played alternately. The performance of the song takes five minutes and twelve seconds which corresponds to the length of the recorded video we used for the analysis.

For the video-based analysis we conducted a preliminary review for basic structuring, a substantive review to discover and annotate important passages and finally an analytic review to study specific parts in detail following an approach suggested by Heath et al. [13]. We identified the major parts of the song, the corresponding location and movement of the guitarist and every use of the smart phone which was also logged in a log file directly in pd. This brought up certain key events. In addition to the video-based analysis we used the personal experience of the first author as the guitarist to extract meaningful information about the application of UniCoMP.

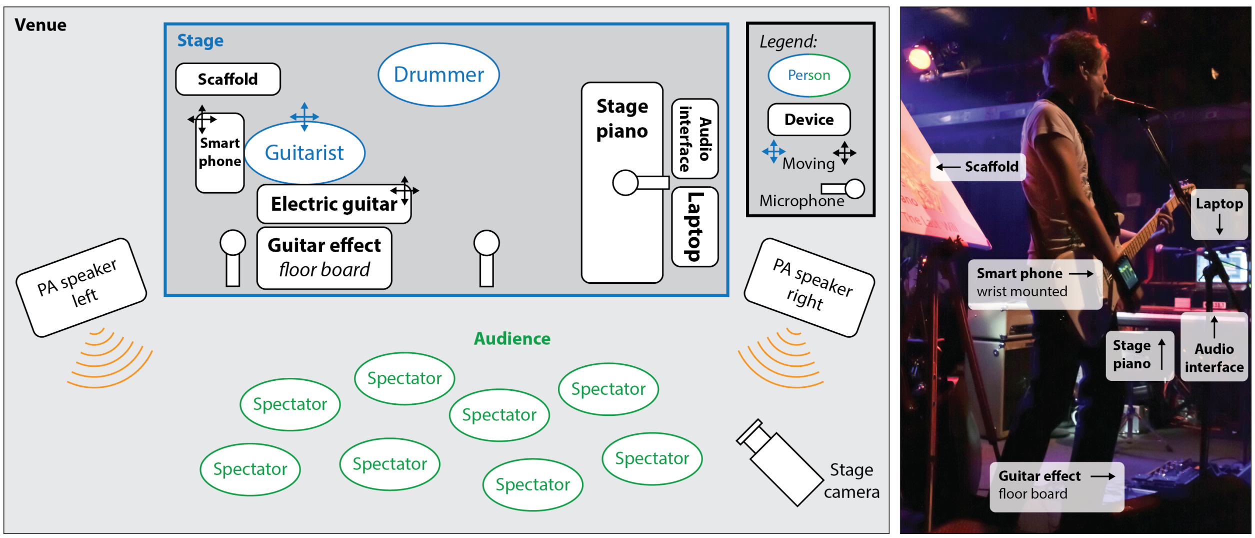


Figure 3. Schematic venue overview for the in-situ study and corresponding picture of the actual performance.

3.2 Results

Overall, the experience of the performance was a positive one for the artist. The system was relatively stable and the artist was able to (mostly) focus on the actual performance of the song, rather than on the device itself. He could also move around on stage according to dramaturgy and control devices remotely.

From video analysis, we created a timeline visualization of the performance, as shown in Fig. 4, and identified four key events, identified as red circles at the top of the timeline.

The operations resulting in the key events 1, 3 and 4 were planned in advance for testing purposes. Key event 2 was not supposed to happen. The events were:

Key event 1 (00:07): Starting the sequencer remotely from the other side of the stage while painting at the scaffold.

Key event 2 (01:43): Adjusting a slider that was manipulated accidentally somewhere between key event 1 and 2.

Key event 3 (02:39): After playing the synthesizer on the stage piano starting to play the synthesizer remotely with the smart phone while moving to the guitar effect floor board at the other side of the stage.

Key event 4 (04:44): Directly after playing the guitar, starting to play the synthesizer remotely on the left side of the stage and start to modulate the sound by moving the hand.

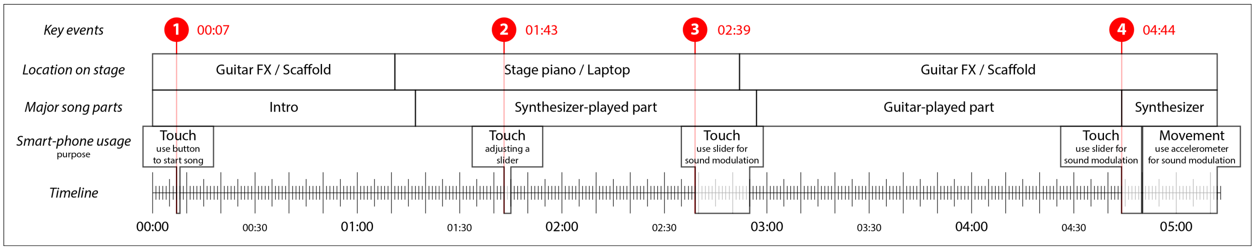


Figure 4. Timeline and analysis of the chosen song.

3.3 Discussion

The video-based analysis of the performance confirms that the application of UniCoMP gave the guitarist freedom to move around the stage according to dramaturgy rather than following given technical and spatial constraints. For instance operating the laptop, controlling the guitar effect floor board and playing the synthesizer immediately consecutively would have been impossible if the devices were distributed on stage and would have constrained dramaturgical aspects of the performance. The key events 1 and 4 show clearly the advantage of controlling devices or playing instruments remotely, when it would not have been possible otherwise due to timing constraints to physically move to a separate controller or instrument. Key event 3 underlines the flexibility provided for moving from one point to another on stage without interruption.

The experiences here suggest that the wrist-mounted smart phone might be a good option for operating purposes during playing an instrument. It is highly accessible at any time and barely disturbing while using the fingers for playing. However, key event 2 also revealed considerable issues with the interface, when a slider appeared misaligned accidentally. Maybe it was inattention of the guitarist, inaccuracy while controlling other interface elements or even another object activating the touch screen through contact. While we were not able to replicate the problem later, it demonstrates that such unexpected incidents can distract the performer suddenly, as experienced here. Even if the artist can immediately react and sort the problem, it can still influence playing or even force the guitarist to stop playing. During our performance the guitarist checked the interface preventively, recognized the problem, waited for a short break in the song which luckily came and readjusted the slider by hand. This finally happened at key event 2.

4 Conclusion

In this paper we presented UniCoMP as a system that enables musicians to play their existing instruments and control devices remotely and flexibly during a musical performance. For realization we used off-the-shelf hardware and software only and conducted a pilot evaluation during a live performance of the first author who is a performing artist. Revisiting our research questions, the findings indicate that UniCoMP increases flexibility regarding playing instruments and controlling sound effects and enables higher freedom of action on stage. Finally the interface can be fully customized and mapped to any MIDI-compliant device which makes UniCoMP potentially highly versatile.

However, during evaluation we could also identify a certain susceptibility to unexpected errors that distract the musician and cause unwanted sound manipulation in the worst case. This points to the need for future work to make UniCoMP more fail-safe and hence available for other artists. Future evaluations could also explore the audience's experience of the performance, plus the use of UniCoMP by other artists using other instruments.

References:

1. Engum, T.: Real-time control and creative convolution. In Proceedings of NIME 2011, pp. 519–522.
2. Manson Guitars: http://www.mansonguitars.co.uk (viewed 10. October 2014)
3. MuseWiki: http://www.musewiki.org/Korg_Kaoss_Pad_KP2 (viewed 10. October 2014)
4. Lähdeoja, O.: An approach to instrument augmentation: the electric guitar. In Proceedings of NIME 2008, pp. 53–56.
5. Reboursière, L., Frisson, C., Lähdeoja, O., Mills, J.A., Cècile, P., Todoroff, T.: Multimodal Guitar: A Toolbox For Augmented Guitar Performances. In Proceedings of NIME 2010, pp. 415–418.
6. Overholt, D.: The Overtone Fiddle: an Actuated Acoustic Instrument. In Proceedings of NIME 2011, pp. 30–33.
7. Fels, S., Lyons, M.: Creating new interfaces for musical expression: Introduction to NIME. In SIGGRAPH09 Courses, ACM Press 2009, pp. 1–158.
8. Dobrian, C., Koppelman, D.: The 'E' in NIME: Musical Expression with New Computer Interfaces. In Proceedings of NIME 2006, pp. 277–282.
9. Ellis, C., Adams, T.E., Bochner, A.P.: Autoethnography: An Overview. Forum: Qualitative Social Research 12(1), 2011.
10. Eriksson, T.: Being native distance, closeness and doing auto/self-ethnography. ArtMonitor 2010.
11. Puckette, M.: Pure Data. In Proceedings of ICMC 1996, pp. 224–227.
12. Reeves, S.: Designing interfaces in public settings. Springer 2011.
13. Heath, C., Hindmarsh, J., Luff, P.: Video in Qualitative Research. Sage Publications Ltd 2010.

Category: Hands-on Presentation

Title: Case Studies for a Digital Music Instrument with Children and Older Adults

Authors: Oliver Hödl[1]

Affiliations:

[1] Vienna University of Technology, Human Computer Interaction Group, Argentinierstraße 8/187, 1040 Wien, Austria

* oliver@igw.tuwien.ac.at

Abstract: The “Trombosonic” is a new digital music instrument based on the foundational principles of the slide trombone. An ultrasonic sensor combined with a red laser allow the performer to play the instrument using similar movements to change the pitch, by moving one hand back and forth even though there is no physical slider available. Furthermore, additional sensors enhance musical expression by gestural movement of the whole interface and by using the breath. Due to its compact size and the lack of a slider, the Trombosonic can be played in many different ways using one or two hands and it can be used to acoustically explore the surrounding environment with the ultrasonic sensor. Two informal case studies, one with a child and one with an older adult, indicate the instrument’s potential for music-related educational purposes and its suitability for people with restricted mobility to play such an instrument. Further development might include a built-in microphone to use the human voice and an expansion of the synthesizer's features.

Category: SHORT PAPER

Title: Towards digital immersive and seamless language learning

Authors: Thomas Strasser[1]*, Wolfgang Greller[1]†

Affiliations:

[1] University of Teacher Education Vienna.

* thomas.strasser@phwien.ac.at, corresponding author

† wolfgang.greller@pwhien.ac.at

Abstract: Modern technologies facilitate new forms of learning. Technology-enhanced language learning (TELL) has seen dramatic changes in the facilitation of self-directed learning opportunities, but also in enhancing the learning experience in classroom-based formal language learning. In our study, we investigate the potential of new technologies and want to find out how immersion teaching is supported through seamless learning approaches.

One Sentence Summary: The paper presents theoretical and practical considerations for digital immersive and seamless language learning in pre-service teacher training.

1. Introduction and concepts

Immersion is one of the key pedagogic concepts in language teaching [1]. The idea behind immersion teaching is to embed learners in a linguistic and cultural environment that is equivalent to that of a native speaker, thus facilitating acquisition of the foreign or second language (FL, L2) in a simulated mother tongue (L1) situation. This method stands beside other more traditional language teaching approaches that focus on the acquisition of linguistic concepts and competences (grammatical, communicative, etc.). Historically, language immersion can be traced back to the post-WWII days with the establishment of Ulpan courses in Israel that aimed to teach Hebrew to new immigrants. In these settings, students were instructed in the Hebrew language and culture for better integration. The idea was taken up in other countries, and, by the mid-1980s, language immersion had developed a strong foothold in various bilingual communities and in the teaching of lesser-used languages in Wales, Quebec, Brittany, and elsewhere [2]. Primarily adult-oriented in the outset, the high motivation and intensity of the approach led to successful learning outcomes and a positive perception by language learners [3]. More recently, the approach has been transferred and somewhat modified to cover ‘content and language integrated learning’ (CLIL) in general foreign language classes. Here, certain subject disciplines are taught in the target language to facilitate not only FL learning but also subject knowledge and competences [4]. Still, despite large similarities, there are also important differences between immersion and CLIL [5].

In technology-enhanced learning (TEL), immersion takes a somewhat different perspective that mainly refers to the perceived technology-facilitated environment, such as 3D worlds, games or ambient learning displays [6, 7]. In this short paper, we propose to merge the two concepts into a seamless language learning experience and to use modern learning technologies to simulate a native environment for immersion.

Seamless learning can be described in a multitude of ways. Conceptualisations and definitions vary from 'the seamless integration of technologies into classrooms […]' to marking 'the border between formal and informal learning or individual and social learning' [8]. Other experts define seamless learning as 'learning wherever, whenever and whatever' [9].

In principle, we see three main bridging functions in seamlessness: (1) formal – informal; (2) across devices and applications; (3) blended learning, i.e. scenarios spanning online and offline episodes of learning. Taking the conceptual and terminological versatility of seamless learning into consideration, a certain consensual approach in the scholarly literature can be noted, though:

> However, common to most definitions is the aim to support continuous, fluid learning experiences – mainly driven by the learner's desire to inquire or to investigate. The concept of seamless learning is to make the transitions between the different learning situations and context as smooth as possible. [10].

The question arises how technology can make a language learning experience fluid and student-centred, focusing on learning/teaching designs that span different activities and contexts. The following chapter seeks to investigate formal and informal learning contexts (mainly at tertiary level), their applicative scenarios and consecutively their conceptual proximity to seamless learning.

2. Formal/informal learning and its relation to seamless learning

There is little doubt that technological innovations like the Internet have initiated a vivid discussion concerning the reformation or adaptation of higher education in general [11-15]:

> Higher education is a dynamic, complex system embedded in an even more dynamic and complex supersystem - human society. Technological innovations have radically changed this supersystem […] [16].

However, Wiley [16] suggests that especially technological developments have often not been didactically implemented in tertiary education curricula:

> While commercial industries have converted these technological advances into consumer benefits, thereby making customers happier and improving their own financial bottom lines, higher education has largely ignored these changes in its supersystem.

In his paper, Wiley explicitly emphasises a certain shift concerning learning techniques in the digital age from formal, institution-based education to everyday or informal learning (learning in an extra-curricular setting [12]). In general, Wiley argues that formal learning within an institutionalised context (seen from a learning-theoretical point of view) is something analogue, tethered, isolated, generic, consumption-oriented and closed, whereas informal learning (e.g.

situated, ubiquitous and extra-curricular learning) focuses on digital, mobile, connected, personal, constructivist and open learning performances and therefore pays conceptual attention to the technological developments of the 21st century (see figure 1, [16]).

Education		**Everyday**
Analog		Digital
Tethered		Mobile
Isolated		Connected
Generic		Personal
Consumers		Creators
Closed		Open

Figure 1. Wiley's dichotomy education vs. every day (i.e. formal vs. informal learning) [16]

Informal or everyday learning within a digital context is frequently carried out with mobile devices such as the smartphone or a tablet-PC [13, 17, 18]. In order to establish a holistic, fluid and ‘seamless’ learning approach, it is of great importance to consider the mobile device as a ubiquitous interface between state-of-the-art culture, everyday life and a learning-outcome-oriented and student-centred learning in the classroom [17].

Ubiquitous learning means that students can learn *wherever* and *whenever* they want, but does not explicitly imply or emphasise the idea of establishing a fluid and smooth transition of learning experiences between different settings (e.g. classroom and informal learning). Seamless learning, on the other hand, seeks to create coherent and interdependent learning designs by considering learning in class and learning in context as one interconnected learning space without local and conceptual borders. The learning space is open [16] and rejects the dichotomy of formal/informal learning as two separate learning environments.

Seamlessness in informal learning environments also takes note of the context and changes thereof. In order to facilitate that learning in a situated, ambient, and open space-time can happen, the design ideally provides more than just content items [7].

To promote the approach of seamless learning, various studies suggest that “seamlessness [is] achieved by bringing the same artefacts (data on mobile devices) into different social settings and times.” [8]. The learner therefore gathers, processes, and (re-)shares various artefacts (i.e. learning objects) in different social and local settings and considers the reflection on those artefacts as a holistic learning performance (independent from space, time and setting). In our approach, however, we aim to de-emphasise the content objects/artefacts, and instead focus on the learning interaction design for immersion, thereby creating a learner-centred overarching experience that is both, situated and outcome-oriented.

3. Good Practice of seamless language learning

3.1. Seamless language learning with smartphones and e-portfolios. An overview.

At the University of Teacher Education Vienna, the approach of seamless language learning is put into practice. Various curricular stakeholders and researchers suggest that lifelong learners at tertiary level should try to overcome pre-conceptualised learning borders. This is to say that a learner should not think in terms of formal vs. informal learning [19, 14]. Therefore, the approach of an interdependent, interconnected, coherent and fluid education scenario is of great relevance especially when educating future (language) teachers. Several chosen groups of EFL (English as a foreign language) students use their smartphones and the ePortfolio platform Mahara to bridge institution-based and informal learning contexts. Students are asked to use smartphones to create episodes of situated student-centred learning, which means that the curricular input of the EFL-lectures/seminars are extended with mobile-phone-assisted learning activities. The self-determined learning spaces (= episodes of situated learning) extend the 'learning path' of the student [20]. The following short didactic scenario exemplifies the seamless language learning approach further:

3.1.1. Curricular input within a classroom based context.

During the EFL seminar, students receive theoretical and practical instruction on how to improve their monologic speaking skills (e.g. fluently talking about a certain topic [21-23]).

3.1.2. Creation of linguistic artefacts in transferred settings.

In dedicated sessions (e.g. school practical studies for EFL students, etc.) students learn to use smartphone apps to create audio recordings (focusing on theoretical and practical aspects, how to focus on intonation, rhythm, stress, etc.). Then they are asked to produce several artefacts which supports the self-evaluation of their linguistic production (speaking skills): they record themselves in different situations (at university, at home, etc.) talking about certain seminar-related topics (e.g. the life of an English teacher in Vienna, documenting ELT-related activities, reflecting their lesson performances, and so forth) and articulating their ideas in the L2 independent of time and space. Alternatively, they can use an Avatar recording app like Voki (www.voki.com).

3.1.3. Sharing/documenting/discussing artefacts in an ePortfolio.

After having recorded themselves and practised the act of monologic speaking about a certain topic (remedial drill-and-practice patterns), students are asked to upload the audio file (produced with their smartphone application) to their personal ePortfolio (in Mahara). The students then invite their peers and tutors to give constructive feedback on their spoken performance (feedback on discursive strategies, lexical/grammatical accuracy, coherent logic, etc.) [24]

3.2. Empirical evaluation of ePortfolios and seamless language learning

In order to back up the descriptive lines of argumentation concerning the use of ePortfolios and integrated seamless language learning, some empirical data [25, 26] will be presented. In the course of a research project at University of Teacher Education Vienna (2011-2013, "The use of ePortfolios in teacher education"; with an emphasis on self-regulated language learning), the following scientific focal points were formulated:

1. What is the general perception (positive or negative) of Mahara among pre-service teachers after 1.5 years of ePortfolio usage in the course of school practical studies/EFL seminars?
2. Which Mahara-internal and external tools are being used in a certain didactical context (including reflection, feedback sessions, learning outcomes). How often are they used?

In the second year of the research project, a questionnaire with 27 questions (multiple choice and open questions) was designed for 220 students (pilot group, lower secondary and primary school pre-service teachers). 147 questionnaires were returned (i.e. 66,8 %). Furthermore, four semi-structured interviews were carried out with students.

Since it is part of the institution's curriculum to continuously use ePortfolios for pre-service teacher training especially in school practical studies, it seemed to be legitimate to ask for a general tendency concerning the perception of ePortfolios among students. The authors of the questionnaire deliberately formulated the following question in quite a general way in order to receive a quick response concerning perceptive tendencies: "If you had the chance to decide whether to continue using Mahara or not, how would you decide? O yes O no".

From the 147 respondents 85 (i.e. 57%) want to continue using Mahara. From the perspective of the stakeholder and the project group, this figure is quite satisfactory, since speaking from a globally-semantic point of view a general majority of the students appreciate the use of Mahara, which can be seen as a solid basis for a continued use of ePortfolios with the determined need to constantly increase these figures in the implementation phase.

Analysing the data within the empirical segment "The use of Mahara-internal and external tools" (cf. research question 2, e.g. upload of audio files, etc., see chapter 3), the following recurring pattern concerning seamless learning outcomes can be recognised (mainly based on open questions): In certain groups (e.g. 3rd semester lower secondary school teachers and 1st semester primary school teachers) it can be seen that Mahara does not only serve as a simple archive of artefacts but also as a dynamic, seamless interface for communicative and self-regulated learning [27]; cf. students' recordings of spoken artefacts including reflective performance as a part of their tasks in the EFL seminars). Within these groups, 23 people indicated that Mahara's journal (internal blog tool) is frequently used for reflective processes (blogging about their personal speaking performance). 27 students indicated that several external tools (e.g. audio player plug-ins) are continuously used to display or disseminate their produced artefacts (cf. audio recordings). Within the context of the semi-structured interviews with students, many of them explicitly uttered that the use of Mahara's journal function (blogging about your spoken performance, receiving constructive feedback on their linguistic performance by peers not only professors) in combination with simple but effective audio plug-ins (e.g. embed the recorded audio file into their personal learning environment) helped them to continuously become aware of their linguistic strengths and infelicities (pronunciation, grammar, lexical mistakes) due to constructive chunks of feedback. Especially 'inhibited' (character attribute based on self-assessment by students in the course of semi-structured interviews) students had the chance to record their spoken performances over and over again until they believed their produced artefacts are suitable for meeting the demands of the original task (also considering in-between feedback by students and professors via the journal). Furthermore, they did not experience such a pressure as it would occur when performing their oral presentation within a formal classroom setting. Therefore, positive developments concerning certain learning outcomes (here: improvement of spoken performance) can be empirically noted. In addition, students reported that due to the fact various performative artefacts can be uploaded/edited/adapted (here: audio recordings) within an explicitly ubiquitous, dynamic and informal context (artefacts can be uploaded from almost everywhere), students can focus on their tasks/performance in known surroundings (e.g. at home) which often contributes to a more effective seamless learning experience.

3.3. Benefits of seamless language learning

By making students aware that the language learning designs can be considered as something fluid (formal and informal learning being coherently linked), unrestricted in space and time (ubiquitous production/reflection of learning products) and multi-sensory (using audio, video, images, etc.), they realise that learning need not be categorised either as strictly institutional or informal. The well-designed blend of lessons, mobile technology, and artefact curation tools like ePortfolios supports the language learning process to appear more holistic without the constraints of traditional lesson structures. This fluid and ubiquitous learning process using different levels of interactivity and construction of knowledge/competences helps students become more aware of the fact that they can provide peer support or practise certain linguistic patterns (here the production of grammatically, lexically and topically coherent monologic spoken texts) whenever it suits them best.

Due to the technological simplicity of several audio recording or Avatar applications [28], students are able to record and re-record themselves as often as they like (whenever and wherever) and submit their final learning product when they think it meets the curricular demands. If the students are not really satisfied with their recording, they can bring it to the physical classroom or the virtual sharing space, discuss it with peers and teachers, adapt it, improve and finalise it. Here, seamless learning means establishing a fluent local interdependence of learning outcomes. Furthermore, students are given the chance to continuously reflect and document progress by using an ePortfolio.

Another benefit is the inherent flexibility of the learning activities. Whenever a student has another idea on how to improve their recording, they can immediately access it via their smartphones or ePortfolios (from home, on the move, in class) and adapt it to the needs of the momentum. Therefore, seamless learning supports the idea of immediacy as a continuous, rapid reflection process. With the support of the tutor, their peers and the use of complementary technologies, students can overcome being mere recipients of transferred knowledge, but directors of their own learning.

The seamless scenario described above can be considered as "open" or "flexible", where formal and informal learning converges (since the learners can improve or modify their audio recordings anytime anywhere). Even more importantly, in this spatial and temporal openness, the formal learning design is extended into the "real world", and, therefore, includes specific cultural codes of discursive and behavioural patterns adapted to general frameworks of society, e.g. how to give constructive feedback on their peers' audio recordings, how to critically reflect on one's own linguistic performance, etc. What is more, the learning design becomes situated as learners are challenged with developing awareness of real-life contexts (i.e. situations they encounter while developing their artefacts). Due to the fact that the learners also continuously work or reflect on their learning products (their audio production) within an *everyday life* context, the learning experience per se becomes more authentic than the one in a traditional classroom-based situation.

4. Towards digital immersion and seamlessness.

We'd like to come back to the original concept of enabling digital language immersion using seamless learning designs. In our short example above (i.e. a seamless learning scenario), we captured one individual element of FL learning. To achieve digital immersion using the full potential of modern learning technologies, many targeted and complementary learning designs, addressing different linguistic and cultural competences such as comprehension, production or feedback/reflection skills need to be applied. These can be structured against expected outcomes along the lines of the Common European Framework of Reference for Languages (CEFR; Council of Europe 2002). Several attempts using augmented reality have already been undertaken and evaluated, including the description of requirements for a contextualised multi-platform learning framework [29].

What we would like to stress, however, is that immersion teaching has a firm rooting in cultural authenticity and this is often not served by language learning lessons no matter how advanced the technology that's being used might be. Seamless scenarios developing cultural competences, therefore, should in our view become an integral part of seamless TELL. Understanding cultural concepts of a foreign language, regionalisms, dialects/accents and sociolects, therefore, need to be designed into the language learning experience and exposure of students. Designing cultural and contextual experiences for language learners can, in our opinion, lead to more comprehensive competence building, and the use of modern mobile, immersive and ambient technologies can provide the necessary connective environment to facilitate this.

References and Notes

[1] NCR: National Center for Research on Cultural Diversity and Second Language Learning, *Integrating Language and Content: Lessons from Immersion* (1995, available at: http://www.cal.org/resources/digest/ncrcds05.html)

[2] C. Baker, *Foundations of Bilingual Education and Bilingualism.* (Multilingual Matters, Clevedon, 1993).

[3] C. Jones, The Ulpan in Wales: A study in motivation. *Journal of Multilingual and Multicultural Development* 12/3, 183-193 (1991).

[4] C. Dalton-Puffer, Outcomes and processes in Content and Language Integrated Learning (CLIL): current research from Europe. *Future Perspectives for English Language Teaching*, N.N. (2008) (available at: http://www.univie.ac.at/Anglistik/Dalton/SEW07/CLIL%20research%20overview%20article.pdf)

[5] David Lasagabaster, Juan Manuel Sierra, (2010). Immersion and CLIL in English: more differences than similarities. *ELT Journal* 64/4, 367-375 (2010) (available at: http://laslab.org/upload/immersion_and_clil_in_english:_more_differences_than_similarities.pdf)

[6] S. DeFreitas, Learning in Immersive worlds - A review of game-based learning. *E-Learning Series* (2006) (available at: http://www.jisc.ac.uk/media/documents/programmes/elearninginnovation/gamingreport_v3.pdf)

[7] D. Börner, M. Kalz, M. Specht, *A Conceptual Framework for Ambient Learning Displays.* Joint Proceedings of the Work-in-Progress Poster and Invited Young Researcher Symposium for

the 18th International Conference on Computers in Education, Putrajaya, Malaysia (2010) (available at: http://dspace.ou.nl/bitstream/1820/2827/1/ICCE_CUMTEL_submission.pdf)

[8] M. Gruber, A. Cooper, C. Voigt, *Seamless learning (U-Learn)* (2012, available at: http://www.learningfrontiers.eu/?q=content/seamless-learning-u-learn)

[9] Tak-Wai Chan, Jeremy Roschelle, Sherry His, Mike Sharples, Tom Brown, One-to-one technology-enhanced learning: an opportunity for global research collaboration. *Res. Practice Tech. Enhanced Learning* 01 (01), 3-29 (2006).

[10] Chee-Kit Looi, Peter Seow, BaoHui Zhang, Hyo-Jeong So, Wenli Chen, Lung-Hsiang Wong, Leveraging mobile technology for sustainable seamless learning: a research agenda. *British Journal of Educational Technology* 41 (2), 154-169 (2010).

[11] J. Cross, *Informal Learning. The other 80%* (Internet Time Group, 2003) (available at: http://www.commonknowledge.org/userimages/resources_peer_assist_guidelines+.pdf)

[12] G. Siemens, *Connectivism* (2004, available at: www.elearnspace.org/Articles/connectivism.htm)

[13] John Cook, Norbert Pachler, Ben Bachmair, Ubiquitous mobility with mobile phones: a cultural ecology for mobile learning. *E-Learning and Digital Media*, 8 (3), 181-196 (2011).

[14] A.L. Etxeberria, Ed., *Global e-learning.* (UDIMA, Open University, Madrid, 2012).

[15] J. Casey, W. Greller, *Jane Austen and the Belly of the Beast: Commodification, Technology and the Open Agenda in Higher Education*, Presentation at the Goldsmiths Learning and Teaching Conference, London, UK, 30 May 2014. (available at: http://www.gold.ac.uk/gleu/conference2014)

[16] D. Wiley, *Openness, Dynamic Specialization, and the Disaggregated Future of Higher Education.* (2009, available at: http://www.irrodl.org/index.php/irrodl/article/view/768/1415

[17] N. Pachler, B. Bachmair, J. Cook, *Mobile learning. Structures, agency, practices* (Springer Science + Business Media, New York, 2010)

[18] T. Strasser, in *Global e-Learning,* A.L. Etxeberria, Ed. (UDIMA, Open University, Madrid, 2012), pp. 135-144.

[19] European Commission, *Digital Agenda for Europe. A Europe 2020 Initiative* (2012, available at: http://eacea.ec.europa.eu/llp/about_llp/about_llp_en.php).

[20] K. Friedrich, B. Bachmair, M. Risch, Eds., *Mobiles Lernen mit dem Handy. Herausforderung und Chance für den Unterricht.* (Beltz, Weinheim, Germany, 2011)

[21] M. Byram, Ed., *The Common European framework of reference. The globalisation of language education policy* (Multilingual Matters, Bristol, 2012).

[22] Council of Europe, *Common European Framework of Reference for Languages. Learning, teaching, assessment* (Language Policy Unit, Strasbourg, 2001) (available at: http://www.coe.int/t/dg4/linguistic/Source/Framework_EN.pdf)

[23] K. Morrow, *Insights from the Common European Framework* (Oxford University Press, Oxford, ed. 2, 2004)

[24] T. Strasser, H. Knecht, in *EPIC2012. ePortfolio & Identity,* S. Ravet, Ed. (ADPIOS: France 2012), pp. 38-47 (available at: http://www.epforum.eu/proceedings/2012)

[25] T. Strasser, H. Knecht, in *Journal für LehrerInnenbildung, Social Media in der Lehrerbildung,* K. Mayrberger, Ed. (Facultas, Vienna, 2013), 4/2013, pp. 23-28.

[26] Empirical data based on questionnaires and semi-structured interviews, cf. www.mahara.phwien.ac.at and [25]

[27] P. Baumgartner, S. Zauchner, R. Bauer, Eds., *The Potential of E-Portfolios in Higher Education* (StudienVerlag: Innsbruck, Wien, Bozen, 2009).

[28] T. Strasser, in *Revista New Routes*, 51, J. Scholes, Ed. (DISAL, Brazil, 2013), vol. 51/2013, pp. 14-18.

[29] T. De Jong, *Contextualised Mobile Media for Learning.* (Open University: Heerlen, the Netherlands, 2011).

Category: Paper

Title: Developing Future 3D Virtual Learning Environments for High School and Vocational Education

Authors: Tanja Ryymin, Anni Rantakokko, Pasi Mattila, Leena Arhippainen.

Affiliations:

Center for Internet Excellence, Oulu, Finland.

{tanja.ryymin, anni.rantakokko, *pasi.mattila, leena.arhippainen}@cie.fi.

P.O. Box 1001, FI-90014 University of Oulu.

Abstract: This paper describes the changes required in the teaching methods and operational culture of schools to foster the learners of the 21st century, with a focus on increasing the use of 3D technology. Also a project responding to the challenges is introduced, as the School Innovation and Learning Center project has a particular focus on implementing new learning methods in high school and vocational education with the help of 3D technology. With regard to developing 3D virtual learning environments, an immersive 3D virtual learning environment under development in the project will be introduced as an example of the matter.

One Sentence Summary: Towards new learning methods in high schools and vocational education with the help of increasing the use of 3D virtual learning environments.

Introduction: While the digital world and operational culture have rapidly faced tremendous changes during the past years, the educational methods used in schools have still remained fairly similar for a long time [1]. These methods fail to support the needs of the learners of today as they concentrate more on memorizing facts than developing deep conceptual understanding which is the main skill learners need in the 21st century [2]. In general, learning and work life demand 21st century skills such as problem-solving skills, self-regulation, creativity and innovation skills, communication and collaboration skills and the ability to use different kinds of technology [3]. Also life-long learning and constant development are needed. However, these skills are not currently widely taken into consideration in many educational environments and a constantly increasing amount of students seem to experience schools as places that are separate from the rest of the society and thus feel that the skills and information focused on in school are not relevant to them.

Thus, there certainly is a need to review the teaching and learning methods widely used in schools and to see the potential in open-mindedly trying out and developing new types of learning in school [1]. It has been stated that technology has a lot to offer in supporting different kinds of learning methods and developing skills needed today [4]. 3D technology and virtual learning environments have also several learning affordances as they, for example, can improve the transfer of skills and knowledge to real life situations and support richer collaborative learning. [5] Teachers have an essential role in bringing in new methods and changing practices inside the schools. To succeed in that they need support from other teachers and management and they need to understand why the change is required.

In this paper, we will first discuss the change that is needed in the operational culture and teachership in all the levels of the educational system, approaching the topic from a perspective of implementing 3D virtual learning environments in educational practices. The School Innovation and Learning Center (SILC) project focusing in this matter is also presented as a practical example of how the implementation of new technology and especially 3D learning environments could be supported through trainings. Secondly, we will introduce a virtual 3D learning environment under development in the project in more detail and discuss some of the possibilities for future development.

Developing Operational Culture through 3D Technology: In formal schooling, there are two main groups that work side by side during school days: learners and teachers. Although the management teams of schools have responsibility in guiding the operational culture of schools towards a certain direction, teachers are also in a key role when implementing new technology as they bring new methods and ideas into formal learning situations. The role of teachers is shifting more and more from transmitting knowledge towards guiding and supporting learners to construct knowledge themselves, building on prior knowledge [2]. Thus, the biggest challenge is to get teachers to be prepared to adjust their practices towards guiding the learners and implementing new kinds of technology to their teaching in meaningful and motivational ways. Adapting new strategies into school could and should eventually lead into changes in the operational culture of the school and in the role of teachers. For example co-operational working in different kinds of teams including teachers and students to construct knowledge and support learning could be an essential part of the new practices.

3D Virtual Learning Environments in Education. As discussed earlier, especially information and communication technology has developed in huge steps during recent decades and is used widely in everyday life. However, the use of technology in classrooms and in education in general can still be considered to be rather inefficient and focusing merely on storing information, although there are plenty of disposable technologies that could be used to support learning. For example, technology could be used to facilitate the finding, sharing and storing of knowledge, making learning processes visible and offering tools to communicate with others. Especially 3D virtual learning environments have substantial potential in enriching learning by bringing new kinds of learning methods into school.

3D virtual learning environments can provide teachers and learners with fascinating new motivational, collaborative and flexible solutions for educational purposes. There are many practical learning methods that 3D virtual learning environments enable to be used, as they could for example be utilised in simulations or training games to make learning more enhancing and practical in situations that could not be practiced in real life [6, 7]. Thus, using 3D virtual learning environments can significantly support including different types of learning, such as collaborative and phenomenon-based learning, in education. They can be used as multi-user social collaboration platforms, for example, in distance education as they offer a shared space or place despite the location of learners and enable the feel of social presence which has a crucial role in collaborative learning situations. 3D virtual learning environments can also support the development of self-regulation, as they facilitate giving students responsibility and placing them in the center of their own learning [8].

In future, in addition to providing new learning methods, 3D virtual environments could also be used to help users to share their viewpoints and participate in the process of planning new or renovating old school buildings and learning spaces. The same environment could then also be utilised as a virtual 3D learning environment both during and after the designing and building process, for example, in the same style as in the SILC Virtual School which will be introduced in Chapter 3.

SILC Project. The SILC project was established to respond to the growing needs to find new kinds of solutions and approaches to education. Its main goal is to develop learning methods in high schools and vocational education with the help of increasing the use of technology and especially 3D virtual learning environments. In practice, the SILC project has provided teachers with trainings and practical examples of the use of 3D virtual learning environments in education.

As the major challenge regarding the use of technology in schools is often linked to implementing new strategies and changing the operational culture, the main purpose of the SILC project is to focus on putting 3D technology into practice in the everyday life of schools. The goal is to develop solutions that support teaching, leadership and management systems and the development of both in virtual and physical learning environments. In the SILC project, the challenge of introducing new practices to school is responded to by organizing both pre-service and in-service trainings for teachers to provide them with practical ideas and tools to support the use of 3D technology in their teaching. So far, trainings have been arranged in high schools and in vocational education around Finland.

Description of the Virtual Kastelli School: During the SILC project, already existing 3D virtual learning environments, such as the TOY environment from the Future Learning Environments project in the Future School of Finland program, have been evaluated to provide information for further development of future virtual learning environments [9-11]. Also interfaces connecting 3D virtual learning environments with physical learning environments have been explored [12]. These research outcomes have been used to develop new 3D virtual learning environments in the project such as the Kastelli School which will be introduced in this Chapter.

Overview of the Virtual Kastelli School. Currently, a new 3D virtual learning and training environment is under development in the SILC project (Figure 1 and 2). This environment is going to act as an example of a practical virtual learning environment and also have a role in developing the operational culture of a new community center of Kastelli in the city of Oulu, Finland. The new 3D virtual learning environment includes a 3D model of the high school wing of the actual community center building that was inaugurated in autumn 2014. There is also tools for learning and teaching, such as communication tools, as well as a furnishing library allowing the users to modify the spaces to suit their needs. Although the virtual Kastelli School is mainly for fire safety training, the users can also utilise it for other learning situations. For example, they can furnish one classroom to be used as a distant teamwork space where they can meet and work together in the same space like in physical world.

Figure 1. An avatar of the user is looking view over the Kastelli School.

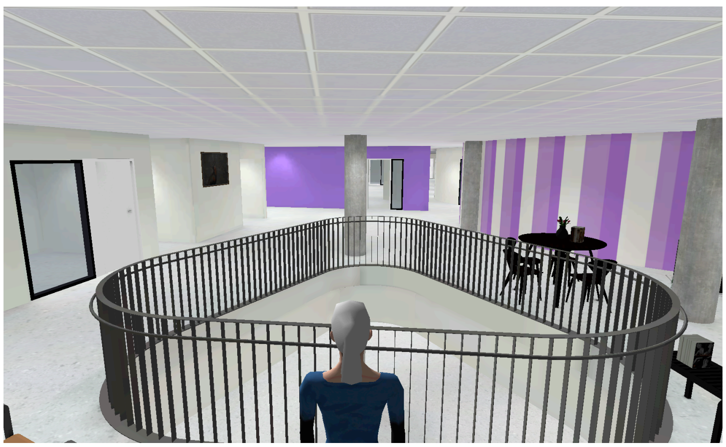


Figure 2. An avatar is moving inside the Kastelli School.

The Used Technology. The 3D virtual environment is created using the realXtend open source platform and will be hosted in the online virtual reality hosting system, Meshmoon, which is a service build on the realXtend. Meshmoon service was chosen because it provides flexible solutions for creating 3D applications, is easy to install to all computers and are free of charge [13, 14]. The realXtend is a multi-user platform which supports online communication and collaboration. The users utilise avatars, virtual representations of themselves, to move and act inside the virtual Kastelli School environment.

Fire Safety Training in the Virtual Kastelli School. With the virtual and physical school environments being similar, it is possible to use the virtual Kastelli School to practice different skills that could be implemented in real life situations when needed. The similarity of the environments can enhance the connection between physical and virtual, and thus also facilitate the implementation of 3D technology in the school. Taking this into account, in the virtual Kastelli School there is a game-like fire safety training simulation that can be used to authentically practice evacuation in fire situations (Figure 3).

Figure 3. Fire safety simulation. The evacuation is in progress and the avatar is trying to find the way out of the burning building.

The community center of Kastelli and its high school wing have a rather complex floor plan with the high school wing being divided in eleven zones which all have different exit routes. In fire situations, there is usually just a few minutes to evacuate from the building and that is why it is important to practice the evacuation from different parts of the school building. In the 3D fire safety training simulation, teachers and students can practice fire safety training in a safe environment without real risk. They need to act like in real life situations and perform certain actions to get through the training; it is also possible to make mistakes and they will finally get feedback on their actions. The simulation has been designed to support the fire and evacuation training that takes place in real life instead of intending to replace it. Still, some features in the virtual fire safety training brings the training additional value, like an interactive evacuation map which is described later in the text.

The virtual Kastelli School provides users with three possible ways to practice fire safety issues. First of all, it is possible to increase the knowledge of how to act in fire situations by reading and watching instructional materials (Figure 4). Secondly, users can practice evacuation from different locations of Kastelli School by using different evacuation routes. In every classroom, there is an interactive evacuation map that displays the shortest evacuation route from the building either by highlighting the path or moving the user through the evacuation route (Figure 5). The third option to practice fire safety issues is to do the virtual evacuation from the school building by starting a fire simulation and the evacuating through the evacuation route that could be practiced in the second stage (Figure 3). All the users have been given access to starting a fire simulation, including deciding where the fire will start and how much time there is for evacuation. When the fire has been started, all the users will receive an announcement of how much time they have to leave the building. They will then exit the building through the evacuation route as in actual emergency situations. It is also possible to run into other avatars and fall, which will slow down their evacuation process. Multiple users can participate in the evacuation simulation at the same time and afterwards they all get feedback from the system (Figure 6). This feedback will show which route they used during the evacuation and if they ran into other users or entered a danger zone.

Figure 4. An avatar (user) exploring the fire safety materials in Kastelli School.

Figure 5. An avatar checking the evacuation route from the interactive evacuation map on the wall. The evacuation route is highlighted by green arrows on the floor.

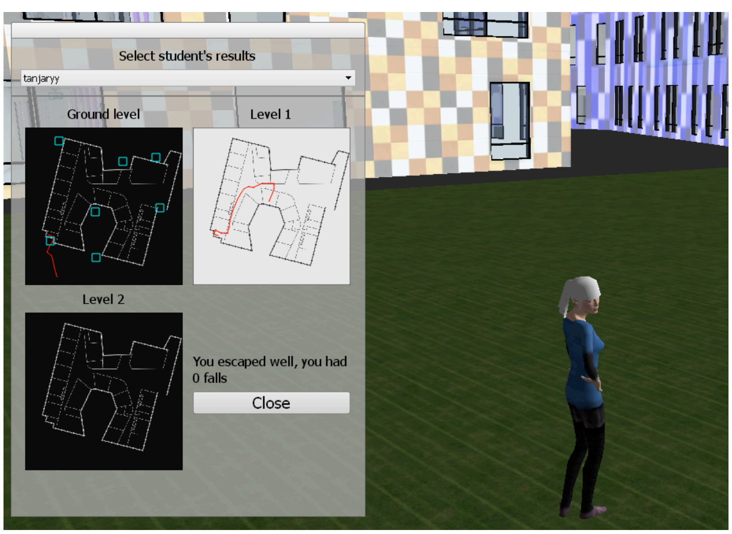


Figure 6. Feedback after evacuation. Red line shows the evacuation route of the avatar.

User Evaluation. The 3D virtual learning environment and fire safety training simulation will be tested in the high school of Kastelli with different user groups such as (a) the students, (b) the teachers and staff, (c) the head team of the community center and (d) safety training professionals. During the autumn 2014 about 100 students (from 700 students) and all the 40 teachers and head team members of the high school are participating in the first user tests in the virtual Kastelli School. After the user tests, a real life evacuation practice will be organised to evaluate the effectiveness of the virtual fire safety training and the impact of the virtual training to real life situations. The evaluation is made by users and fire safety experts and it will provide us with important information on usage of virtual fire safety trainings in school contexts. Although virtual safety trainings have been used for example in mining industry, in a school context they are rather new.

Conclusions: In this paper, we highlight the change required in the operational culture of schools to increase the use of technology and the role of teachers in this change. We also introduce the SILC project and one of its 3D virtual learning environments that is currently under development. By this we demonstrate how the SILC project has responded to the challenges of changing the educational field and society. The SILC project is developing models that will facilitate the updating of the operational culture to suit the needs of learners by supporting the implementation of new technological solutions, especially 3D technologies, in high school and vocational education. The implementation of new technology and methods has often failed because of the lack of time and knowledge of teachers. That is why teachers should be offered practical training and time to adapt to new solutions and practices. It is also essential for teachers to feel dissatisfied about the present situation, see why changes are needed and find new solutions that are meaningful for them. The SILC project has responded to this challenge by offering training and developing models that are easy to scale from school to school and aiming to affect teacher education. The new immersive virtual learning environment of Kastelli School can be seen as a result of this development work. 3D virtual learning environments have great potential in supporting the holistic development of the operational culture of schools by changing the methods used in learning situations instead of merely using a different technology.

References and Notes:

1. Thomas, D., Brown, J. S.: A New Culture of Learning: Cultivating the Imagination for a World of Constant Change, CreateSpace Independent Publishing Platform (2011).
2. Sawyer, K.: The new science of learning. In: The Cambridge handbook of the learning sciences. Cambridge university press (2006).
3. Dede, C.: Comparing frameworks for “21st century skills” (2009), http://watertown.k12.ma.us/dept/ed_tech/research/pdf/ChrisDede.pdf.
4. Goodyear, P., Retalis, S. (Eds.): Technology-Enhanced Learning: Design Patterns and Pattern Languages. Sense Publishers, Rotterdam (2010).
5. Dalgarno, B., Lee, M. J.W.: What are the learning affordances of 3-D virtual environments? British Journal of Educational Technology, vol 41, no 1, pp.10-32 (2010).
6. Hodge, E., Collins, S.: Live in your world, learn in ours. Virtual worlds… Engaging the new generation of students. In: Kay Kyeong-Ju Seo (ed.) Using Social Media Effectively in the Classroom, Routledge, New York (2013).

7. Nelson, B.C., Erlandson, B.E.: Design for Learning in Virtual Worlds. Routledge, New York (2012).
8. Parson, V., Bignell, S.: Using problem-based learning within 3D virtual worlds. In: Wankel, C., Hinrichs, R. (eds.), Cutting-edge technologies in Higher Education: Transforming Virtual World Learning. Bradford, GBR: Emerald Insight (Emerald Group) (2011).
9. Arhippainen, L., Pakanen, M., Hickey, S., Mattila, P.: User Experiences of 3D Virtual Learning Environment. In Proc: 15th MindTrek Conference, ACM Press, 222-227 (2011).
10. Mattila, P., Ryymin, T., Arhippainen, L.:. Learn by playing with your information in a virtual 3D learning environment. In Proc: 1st European Immersive Education Summit, November 28-29, Madrid, Spain, 98-109 (2011).
11. Mattila, P., Krajnak, J., Arhippainen, L., Brauer, S.: Education in 3D Virtual Learning Environment – Case Virtual-Mustiala. In Proc: 2nd European Immersive Education Summit, November 26-27, Paris, France, 134-146 (2012).
12. Mattila, P., Brauer, S., Arhippainen, L., Rantakokko, A.: Towards Immersive User-Friendly Future Learning Spaces in Education. In Proc: 3rd European Immersive Education Summit, November 28-29, London, UK, 111-122 (2013).
13. Meshmoon webpage: http://www.meshmoon.com.
14. realXtend webpage, http://www.realxtend.org/ (2012).
15. CIE webpage, http://www.cie.fi.

Acknowledgments: The SILC project is a three and half a year project (5/2011-12/2014) coordinated by the Center for Internet Excellence (CIE) at the University of Oulu and funded by European Social Fund (ESF) [15]. The project is based on cooperation between several educational institutions, including the Finnish National Board of Education and Finpro. We want to thank all the subjects who have participated to our test in the virtual Kastelli School.

Category: Paper

Title: Determining the Causing Factors of Errors for Multiplication Problems

Authors: B. Taraghi[1]*, M. Frey[1], A. Saranti[1], M. Ebner[1], V. Müller[2], A. Großmann[2]

Affiliations:

[1]Graz University of Technology, Münzgrabenstrasse 35/I, 8010 Graz Austria.

[2]UnlockYourBrain GmbH, Französische Strasse 24, 10117 Berlin, Germany.

*Correspondence to: b.taraghi@tugraz.at

Abstract: Literature in the area of psychology and education provides domain knowledge to learning applications. This work detects the difficulty levels within a set of multiplication problems and analyses the dataset on different error types as described and determined in several pedagogical surveys and investigations. Our research sheds light to the impact of each error type in simple multiplication problems and the course of error types in problem-size.

One Sentence Summary: This work consists in the investigation of the various error types in multiplication problems, as well as the problem-size effect.

Main Text:

1 Introduction: Learning simple multiplications is one of the major goals in the first years at primary school education. Math teachers find pedagogically relevant to know which exercises improve mathematical abilities, which errors occur repeatedly and on which steps they may require teacher's intervention.

Applying math training applications can support the teachers in this regard and enhance the basic math education at primary schools [1]. For example, the 1x1 trainer application [2] that was first developed by Graz University of Technology, assists the training process of pupils and enhances the pedagogical intervention of the teachers for learning one-digit multiplication problems at schools. The application was used in several primary schools for training goals. In our previous works [3, 4] we analysed the gathered data (about 500,000 calculations) to get insight about the learners' answering behaviour within this application. We identified difficulty levels within the set of one-digit multiplication problems. In this work we continue our research on another dataset generated by the Android application UnlockYourBrain, which poses different basic mathematical questions to the learners. The focus is drawn first to the multiplication problems.

We perform the same analysis steps as in our previous work to identify the difficulty levels. We primarily want to shed light to the reasons of the incorrect answers. Therefore, based on the error rates driven from the first part of the analysis, for each multiplication problem we detect different error types known from the literature. We present the probabilities of occurrence of the various error types in detail and explain them individually, for each specific multiplication problem.

Section 2 describes the dataset that is used for analysis purposes. Section 3 covers the difficulty levels of the multiplication problems, the findings and interpretations based on the difficulty probabilities. Section 4 describes the detected error types and proceeds to the analysis of error types in section 5.

1.1 Related Work: There are two major arithmetic models of fact retrieval that deal with errors in simple multiplications; the modified network interference theory by Campbell [5] and the interacting neighbours model by Verguts and Fias [5]. Both models introduce some common error types and their cause in simple multiplication problems.

One of the most occurring error types in simple multiplication problems are the *operand errors*. They happen whenever the failed result is the product of one of the neighbouring operands instead of the given ones; e.g. 48 = **6** * 8 for the given problem **7** * 8. The survey done by Campbell [5], shows that the majority of errors can be classified in this category. The operand error rates differ for each multiplication problem and are not uniformly distributed [7].

Operand intrusion error happens when at least one of the two operands matches one of the digits of the result; e.g. answering **7**4 to the posed question **7** *8. Campbell argued that reading the operands as if they were two-digit numbers causes this error. This argument is supported from the fact that the first operand is observed in the decade digit's place and/or the second operand appears at the unit digit of the result [7, 8].

One of the initial findings in solving arithmetic problems is the so called problem-size effect. The problem size is defined as the sum of the operands [9]. The error rates increase as the problems get larger and the response time evolve correspondingly. The only exceptions are f*ive problems* (problems involving 5 as operand e.g. 5 * 7) and *tie problems* (problems with repeated operands e.g. 4 * 4), that do not exhibit this error to a large extend. These problems can be answered faster in comparison to other problems of the same category [10].

The interacting neighbour model of Verguts and Fias [11] introduces the concept of consistency of multiplication problems. The concept of consistency was formerly known from the language literature [12], where it was proposed that the reaction time to pronounce a given word depends on the consistency of the word to its neighbours, with respect to pronunciation. In the context of simple multiplications, each problem has a set of *neighbouring* problems. The operands that are used in these problems, are the neighbours of the operands (in the multiplication table) of the original problem. Two arbitrary problems are consistent if their solutions have the same decade or unit digits; e.g. 5**6** = 7 * 8 and 3**6** = 4 * 9 are two consistent problems with respect to their unit digit. The authors argue, that the consistency measure explains the problem-size effect as well as the tie effect. Tie problems have less neighbours and they are inconsistent rather than consistent. Hence less competition exists for tie problems. For all *five problems* there are consistent neighbours with distance 2 (they share 5 as unit digit). Although the neighbour distance is far, it is assumed to be the reason for smaller error rates. Altogether, multiplication problems that have a higher consistency with their neighbours can be answered faster with higher accuracy [13].

2 Dataset Description: The learning application that was used to provide insight for the characterisation of learning difficulties is *UnlockYourBrain*. Android users are confronted with basic mathematical questions each time they attempt to unlock their screen. The application provides for each posed question a list of possible answers; only one of them is correct. The list has variable length, meaning that it can vary from trial to trial between two and five possible answers, even if the posed question is the same. The answering process evolves as follows: the learner can either attempt to answer or chooses to skip the usage and continue with unlocking the screen. In case of an answering attempt, either the correct answer is chosen and the application finishes, or a wrong answer is selected. In the latter case the application indicates the mistake and repeats the question with the remaining possible answers. The user reattempts to answer the question with less possible answers or chooses to skip.

The dataset was cleaned to remove noise and was reduced to a minimum number of occurrences of entities in order to ensure a high degree of confidence in the statistical results. The methods used can be read at [14]. The final dataset contained 268 questions that were posed totally 1191450 times to 46357 users.

3 Answer Types and Difficulty Levels of Multiplication Problems: A measure of the difficulty of a question is the answering manner of the learners. The possible answer types are gathered in the following set {*R, WR, W, WWR, WW, WWWR, WWW, WWWW*} where *W* means "wrong" and *R* "right". A question that was posed with three answering options (see [14]) can have three answering types: *R* which denotes that the user found the correct answer in the first answering attempt, *WR* that the first attempt was wrong but the second right and *WW* that both attempts failed. The set of answer types is the classification algorithm's dimensions. Every multiplication lies in an eight-dimensional feature space where the value in each dimension is the probability that the question was answered as the corresponding answer type. By applying the K-Means algorithm [15] in this space we classified the problems in 11 clusters; each of them contains problems that were answered in similar means from the learners.

Figure 1 depicts the computed difficulty probabilities (error rates) of all provided multiplication problems within the dataset. A low probability indicates a rather easy problem whereas a high probability implies a relatively difficult one.

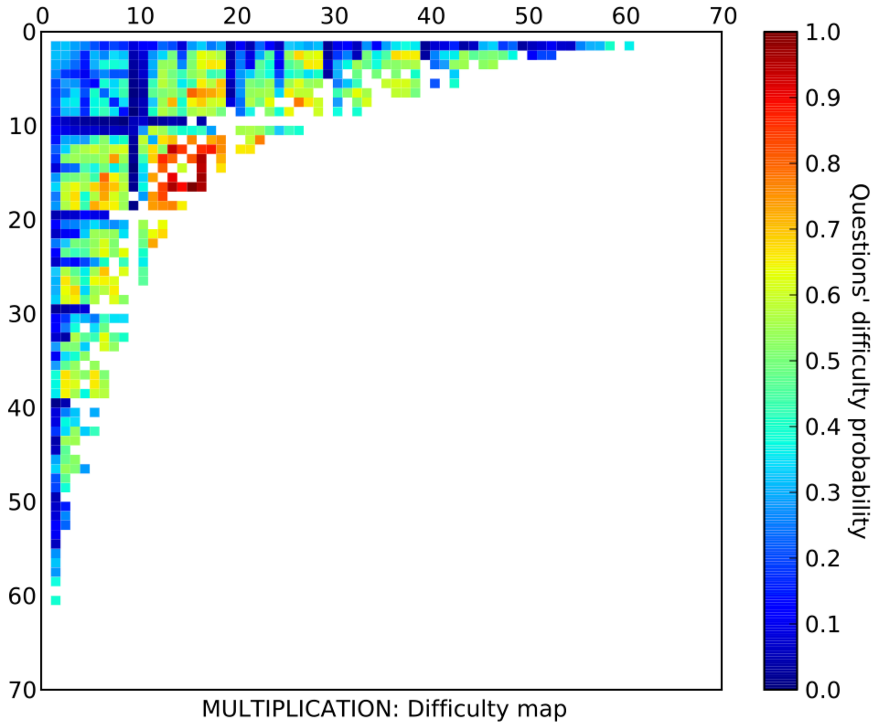


Figure 1. Difficulty map of multiplication problems. Axes stand for the two operands A and B of a multiplication problem A * B. Low probabilities imply lower error rates, hence rather easy problems. High probabilities indicate relatively difficult problems.

It can be observed that the difficulty values appear to a great extent symmetric. The error rate of problems A * B and B * A seem to be strongly correlated, therefore the order of operands probably does not have a decisive influence on the error rate. One-digit multiplication problems are considered easier than the two-digit multiplications. Looking further into the set of one-digit multiplications (the top left quadratic area in figure 1 where both operands are less than ten) we achieve the same results as we gained in our previous research work [3] in the one-digit multiplication problems. *5* and *10 problems* are relatively easier to solve. The problems involving operands 6, 7, 8 and 9 are rather difficult problems.

Looking into two-digit problems, we observe the influence of the 5 and 10 operands in the simplicity of the question containing them. As in one-digit problems, the unit digits 1, 2 and 5 show the lowest error rates. The same is true for *difficult operands*. It can be seen that specially the unit digits 6, 7 and 8 make the two-digit problems extremely difficult relative to the other operands. Considering the problems containing 5 as unit digit, the combination with *difficult operands* as decade digit leads to a higher error rate, compared to the other decade operands.

The *tie effect* is also visible. The problems containing repeated operands have lower error rates compared with other neighbour problems, but the problem-size must be also taken into account. While the tie problems in the interval of one-digit problems are relatively easy, they become more difficult for two-digit problems. The provided dataset in our case contains tie problems no greater than 17 * 17. In figure 1, problems 11 * 11 and 12 * 12 seem easy due to their unit digits (1 and 2 effect); 15 * 15 shows relatively a lower rate than the other tie problems with operands greater than 12 * 12. It can be argued that the use of 5 as one of the operands could explain this phenomenon.

4 Error Types: The complete list of analysed error types with a short explanation can be found in table 1. For a sample given multiplication problem 56 = 7 * 8 an example is given to clarify how to interpret an error type.

Error type	**Description**	**e.g. 56 = 7 * 8**
Operand errors	A neighbouring operand is taken	
Split 1	The neighbouring distance is 1	48 = **6** * 8
Split 2	The neighbouring distance is 2 for an operand or 1 for both operands	40 = **5** * 8
Which operand?	Is the smaller or larger operand affected? Ties were ignored.	
Which neighbours?	Are smaller or larger neighbours taken?	
Operand intrusions	A digit of the result matches an operand	
First operand	Decade digit matches the first operand	74 ⇔ **7** * 8
Second operand	Unit digit matches the second operand	6**8** ⇔ 7 * **8**
Unit consistency	Only the unit digit is correct	7**6** ⇔ 5**6**
Decade consistency	Only the decade digit is correct	**5**1 ⇔ **5**6

Table 1. The analysed error types and their descriptions.

5 Results and Discussion:

5.1 Operand Errors: The majority of errors can be categorized as operand errors. The operand error rates differ for different multiplication problems (see section 1.1). Figure 2 depicts the probabilities of an *operand error* for each simple multiplication problem where each square represents a specific problem. The first operand can be read off the X-axis, the second operand off the Y-axis. The color of the square indicates the probability of an *operand error* occurrence for the corresponding problem; red color indicates higher probabilities and blue color a very low probability. As it can be seen, the problems that are rather difficult (see section 3) are more affected by operand errors than the easy ones.

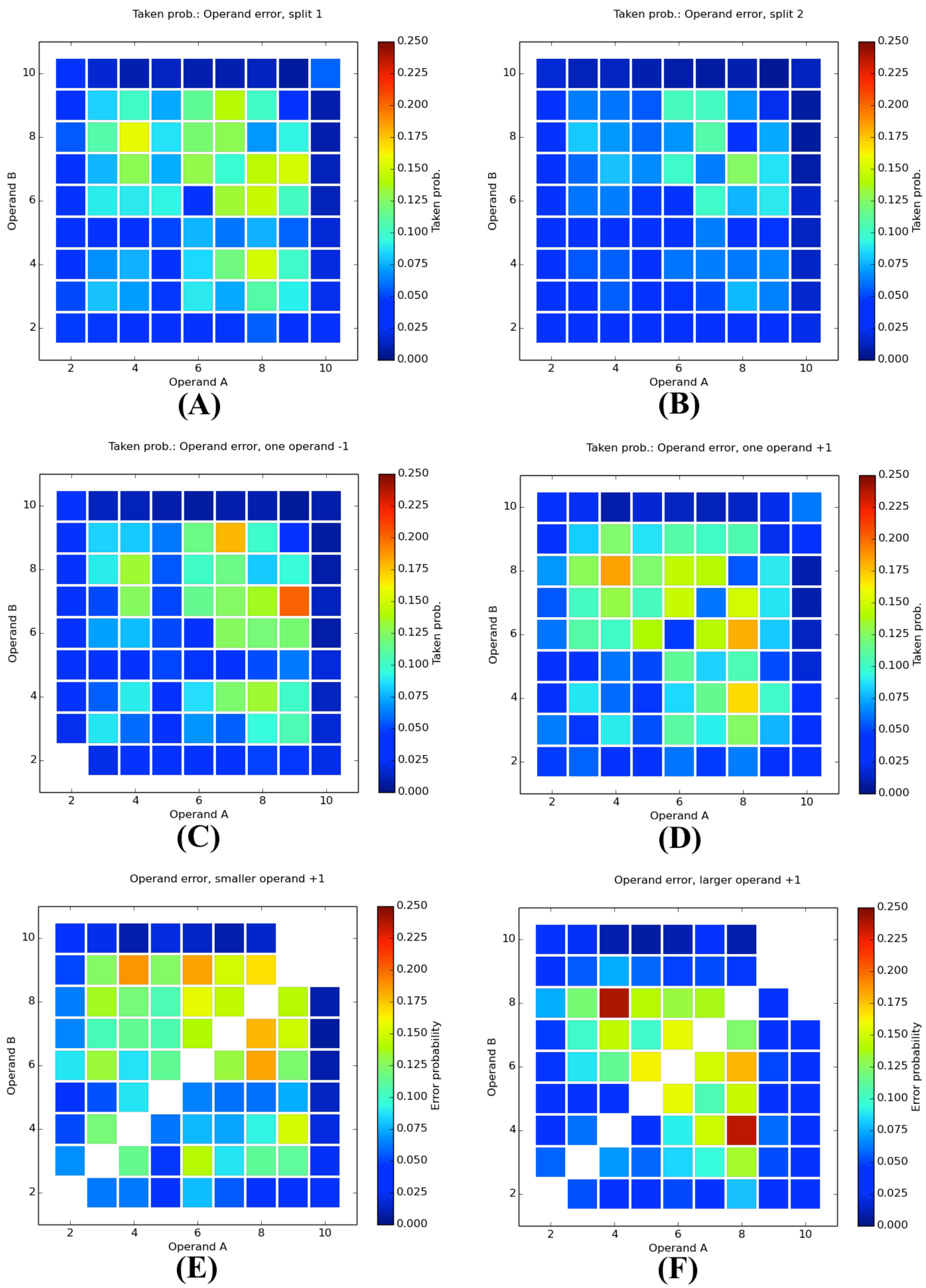


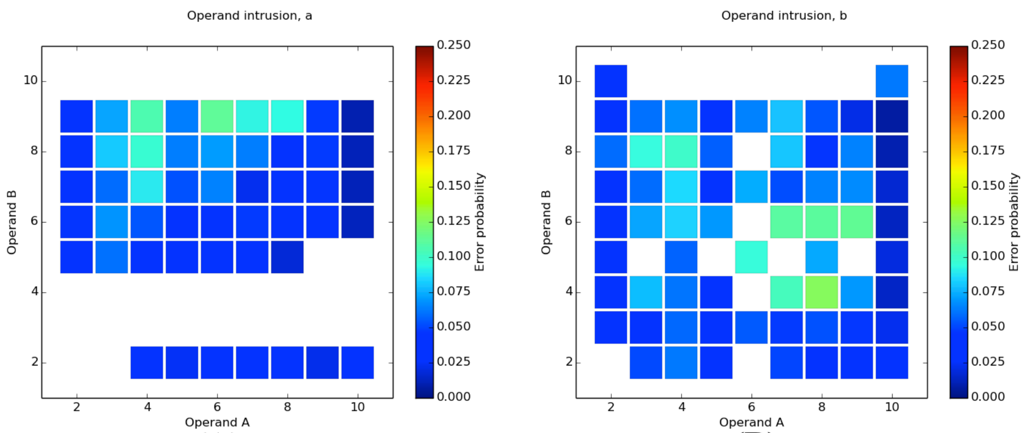
Figure 2. Probabilities (error rates) of an *operand error* for each simple multiplication problem. Figures 2A and 2B compare the error rates of an *operand error* with the split of 1 and 2 respectively. Figures 2C and 2D depict errors with *decremented* and *incremented* operands, respectively. These are restricted to the error rates of operand errors with a split of 1. Figures 2E and 2F compare errors caused by *smaller* and *larger* operands respectively. These are restricted to the error rates of operand errors with a split of 1 incremented.

Figures 2A and 2B show the probabilities of an *operand error* with the split of 1 and 2. Comparing the two heatmaps, it is visible that the shortest neighbour distance (split 1) contains the most operand errors; e.g. for a given problem **7** * 8 the errors such as 48 = **6** * 8 are more probable than 40 = **5** * 8. It is observable that the most difficult problems have the highest operand error rates. Relatively easy problems comprised by operands 2, 5 and 10 show the lowest error rates. This is also true for operand errors with split 2. One can verify that the error rates are also not uniformly distributed over all problems. *Five problems* are less affected from the effects that were described above. We can observe a slightly higher error rate for *five problems* that involve an operand greater than 5 though. It can be argued that the *difficult operands* account for this effect.

Looking further into operand errors with split 1, that account for the majority of errors, it can be observed that the larger operand neighbours are more frequently responsible for the cause of errors than the smaller ones. In other words, learners tend to choose a value greater than the true result of a problem rather a decremented one; e.g. for a given problem 4 * **8** the errors such as 36 = 4 ***9** are more probable than 28 = 4 * **7**. Figures 2C and 2D show this finding. We emphasize that this is a valid prediction for all simple multiplications. Looking further through each multiplication individually, we observe some exceptions such as 9 * 7 and 7 * 9 where a decremented operand is rather due. Furthermore the *tie problems* seem to follow the same rule as can be seen in figure 2D.

Considering the operand errors with split 1 and incremented operands, the next step was to analyse which operand accounts for the error. More specifically, to investigate which one is incremented: the larger or the smaller operand. Our analysis shows that the mean probabilities for the set of larger and smaller operands are extremely close to each other, so that we can not claim that the relative size of operands plays an important role. Figures 2E and 2F show this comparison for each multiplication problem. As an example it can be seen that 8 * 4 or 4 * 8 show a very high error rate, meaning that the most probable false answer in this case was 36 = 9 * 4.

5.2 Operand Intrusions and Consistency Errors: *Operand intrusion* errors occur when an operand intrudes into the result. Figure 3 depicts the error rates for the first operand A and the second operand B respectively. In general the probability of an intrusion for the second operand B is higher than for the first operand A. While no specific pattern can be found within the set of simple multiplication problems, it can be observed that some operands reveal a higher probability relatively to other problems. For instance in case of the first operand intrusion, specially the operand A = 4 shows a probability over 10% while multiplied by difficult operands $B \in \{7,8,9\}$. Interestingly $A \in \{4,6,7,8\}$ are more often intruded to the results while multiplied by B = 9. In case of second operand intrusion, B = 6 reveals a probability of 12% while being multiplied by difficult operands $A \in \{7,8,9\}$. It is followed by $A \in \{3,4\}$ multiplied by B = 8. In both cases, first operands $A \in \{6,7,8,9\}$ play a stronger role in operand intrusion compared with other operands.



(A) **(B)**

Figure 3. Probabilities (error rates) of an *operand intrusion error* for each simple multiplication problem. Figures 3A and 3B show the error rates for the first operand A and the second operand B respectively.

Considering the decade and unit consistency errors, we could find no clear pattern in the multiplication table. The probability of error occurrence related to decade consistency is relatively higher than unit consistency. Decade consistency errors are specially more probable if both operands are greater than 5 and are unequal. The reason for this could be explained by the problem-size effect.

5.3 Problem Size Effect: Problem-size is the sum of the operands and expresses how large the problem is. Figure 4A shows the error rate (of any type) against increasing problem size. As the problem size increases, the error rate has also a tendency to increase. However there is no continuous ascending course of error rate. As predicted in [5, 7, 10] the tie problems can be answered faster and more accurate compared with other problems, also while the problem size increases. We see here that the tie problems have a different course by ascending problem-size. While the error rates for all other error types increases, in tie problems a decrease is observed. This can be claimed only upto problem size 25, due to the fact that the provided dataset for the analysis is restricted. Furthermore, the error rates for the tie problems have a local minimum at 5 * 5, 10 * 10 and 15 * 15, which can be argued by the 5 effect and the easy 10-problems.
We analysed each error type described in table 1 against the problem size individually. Decade and unit consistency errors increase by ascending problem-size. Figures 4B and 4C depict the unit and decade consistency errors against problem size respectively. All other analysed error types do not reveal any increasing course and stay constant within a close probability interval. As an example, the operand error with split 1 is depicted against the problem size in figure 4D. It can be observed that the error rate varies between 5% and 10% and comes even down to about 3% at problem size 25. In sum, considering the set of analysed error types, the problem-size effect can be defined according to the unit and decade consistency errors.

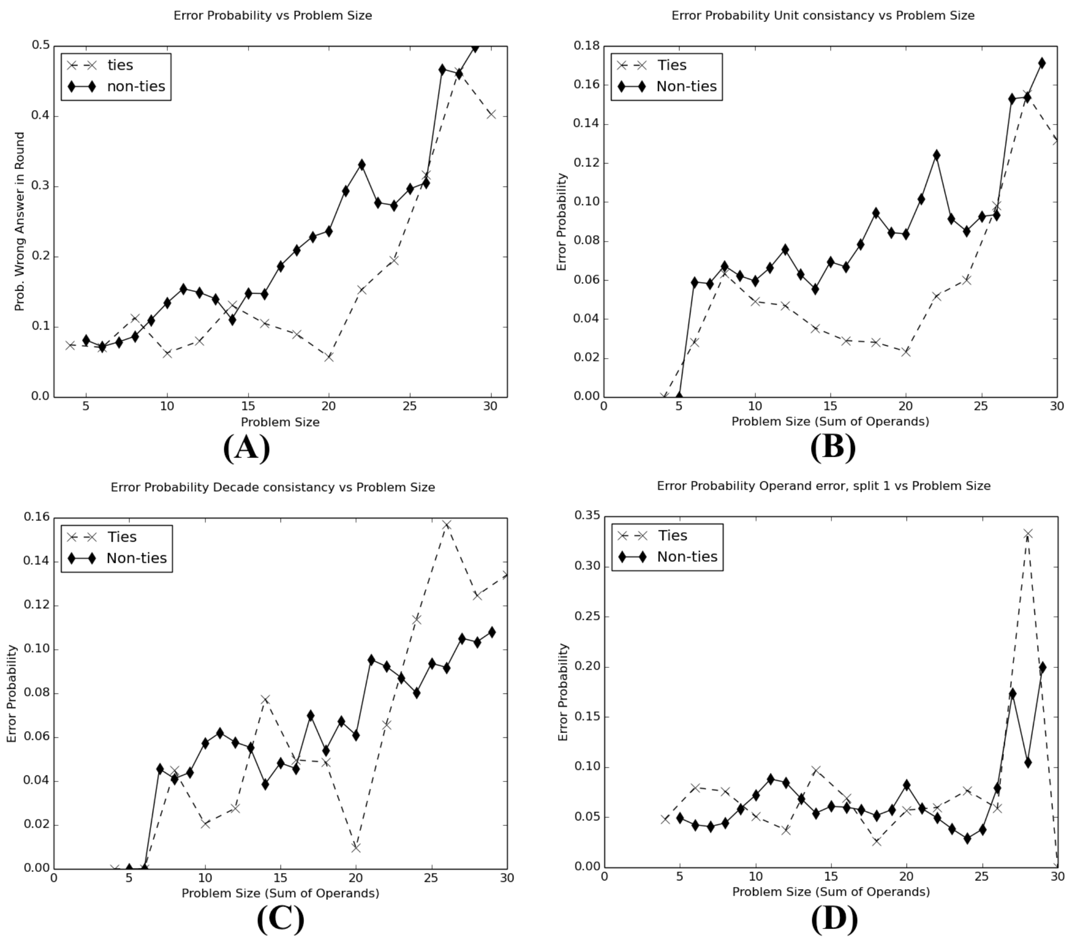


Figure 4. Error probabilities (fraction of errors) against problem size. Problem size is calculated as the sum of the operands A + B. The largest considered operand is 15. Ties and non-ties are depicted separately. Figure 4A shows the general round error probability; that is the fraction of rounds where at least one error of any type has been made against problem size. Figure 4B depicts the unit consistency errors and 4C shows the decade consistency errors against the problem size.

References and Notes:

1. M. Ebner, M. Schön, in *Why Learning Analytics in Primary Education Matters!*, C. Karagiannidis, S. Graf, Eds. (Bulletin of the Technical Committee on Learning Technology 2013) vol. 15, issue 2, pp. 14-17.

2. M. Schön, M. Ebner, G. Kothmeier, *It's Just About Learning the Multiplication Table* (Proceedings of the 2nd International Conference on Learning Analytics and Knowledge ACM, New York, NY, USA 2012) S. Buckingham Shum, D. Gasevic, R. Ferguson (Eds.) pp. 73-81. DOI=10.1145/2330601.2330624.

3. B. Taraghi, M. Ebner, A. Saranti, M. Schön, *On Using Markov Chain to Evidence the Learning Structures and Difficulty Levels of One Digit Multiplication* (proceedings of the 4th International Conference on Learning Analytics and Knowledge, Indianapolis, USA 2014) pp. 68-72.

4. B. Taraghi, A. Saranti, M. Ebner, M. Schön, *Markov Chain and Classification of Difficulty Levels Enhances the Learning Path in One Digit Multiplication,* P. Zaphiris, A. Ioannou, Eds. (Springer LNCS 2014), vol. 8523, pp. 322-333.
5. J. I. D. Campbell, Mechanisms of simple addition and multiplication: A modified network-interference theory and simulation. *Mathematical Cognition.* **1**, 121-165 (1995).
6. T. Verguts, W. Fias, Interacting neighbours: A connectionist model of retrieval in single-digit multiplication. *Memory & Cognition.* **33**, 1-16 (2005).
7. J. I. D. Campbell, On the relation between skilled performance of simple division and multiplication. *Journal of Experimental Psychology: Learning, Memory, & Cognition.* **23**, 1140-1159 (1997).
8. J. I. D. Campbell, J. M. Clark, in Cognitive number processing: An encoding-complex perspective, J. I. D. Campbell, Ed. *The Nature and Origins of Mathematical Skills* (Amsterdam: Elsevier Science 1992) pp. 457-491.
9. N. J. Zbrodoff, G. D. Logan, in What everyone finds: The problem size effect, J. I. D. Campbell, Ed. *Handbook of Mathematical Cognition* (New York: Psychology Press 2004) pp. 331-346.
10. J. A. LeFevre, G. S. Sadesky, J. Bisanz, Selection of procedures in mental addition: Reassessing the problem size effect in adults. *Journal of Experimental Psychology: Learning, Memory & Cognition*, **22**, 216-230 (1996)
11. T. Verguts, W. Fias, Neighborhood effects in mental arithmetic. *Psychology Science*, **47**, 132–140 (2005)
12. M. S. Seidenberg, J. L. McClelland, A distributed, developmental model of word recognition and naming. *Psychological Review*, **96,** 523-568 (1989)
13. F. Domahs, M., Delazer, H., Nuerk, What makes multiplication facts difficult: Problem-size or neighborhood consistency? *Experimental Psychology*, **53**, 275–282. doi:10.1027/1618-3169.53.4.275 (2006)
14. B. Taraghi, A. Saranti, M. Ebner, V. Müller, A. Großmann, Towards a Learning-Aware Application Guided by Hierarchical Classification of Learner Profiles. *Journal of Universal Computer Science, Special Issue on Learning Analytics*, in print (2015)
15. C. Bishop, *Pattern Recognition and Machine Learning* (Springer Science and Business Media, LLC, New York, USA 2006), pp. 424-430

Category: Paper

Stimulating Students Use Web3D-based Technology for Producing Digital Content at K-12 Levels

Jorge Ferreira Franco*, [1, 2]

Affiliations:

[1]Laboratory of Integrated Systems - Polytechnic School of the University of Sao Paulo – LSI/EPUSP, Sao Paulo, Brazil

[2]Ernani Silva Bruno Primary School - Municipal Education Secretary of Sao Paulo Council – ESB/SME/PMSP, Sao Paulo, Brazil.

*Correspondence to: jfranco@lsi.usp.br / ESB/SME/PMSP, Av. Interativa, 100, 02820-020, Parque Taipas, Sao Paulo.

Abstract: Young children have accessed to digital media devices such as computers and mobile phones. These devices have allowed students using third party 3D digital content for enjoying and learning. However, there has been a gap on how to stimulating students at k-12 levels to access, understand and use with awareness a complexity that involves applying a combination of computer science and k-12 curriculum scientific concepts with support of accessible 3D digital technology for producing content. In this paper, an after-school experimental educational project based on hands-on interactive media and information visualization techniques is presented. This project has used a conceptual combination of web3D-based technology, cognitive sciences, learning by doing, action research and immersive education features for stimulating individuals producing 3D digital content through applying the X3Dom framework at K-12 Levels. This work's qualitative contributions have been stimulating students' cognitive competencies such as reading, writing and spatial thinking. It includes digital skills enhancements through human computer interactions and applying computer science features like computer programming and 3D graphics visualization interrelated with k-12 curriculum sciences concepts as math and English language. This learning project has inspired individuals' exploratory lifelong learning and professional attitudes related to researching and producing digital content with sustainability.

One Sentence Summary: This project has stimulated individuals' hands-on web3D technology resulting in lifelong learning and professional enhancements with sustainability.

Introduction

Young children have had access to diverse digital media devices such as computers and mobile phones. These devices have allowed students using third party 3D digital content for enjoying and learning. However, the researched literature [1-5] and this author's long-term action research [6-11] at a primary school, in a developing country, have showed that there has been a gap on how to stimulating and sustaining k-12 students to access, understand and use with awareness the complexity that involves applying a combination of computer science and k-12 scientific knowledge concepts with support of accessible advanced digital and information visualization technologies for producing tridimensional (3D) digital spaces or virtual worlds content.

In this paper, an after-school experimental educational project based on hands-on interactive media and information visualization techniques is presented. This project has used a conceptual combination of web3D-based technology, cognitive sciences, action research and immersive education features for stimulating students' producing 2D and 3D content at K-12 levels through applying web3D based tools such as the X3Dom framework and several low cost multimedia instruments.

Based on action research [13] and human computer interaction (HCI) studies[30], this project's data have been collected via author1's participatory observation, informal emails and talks with current and former students, their publications in blogs integrating 2D and 3D content, video and audio recordings of this project's training sections. The data analyses have showed qualitative results such as stimulating individuals' cognitive and digital skills, including general, scientific and technical knowledge enhancements [9, 10]. These knowledge enhancements have impacted on their exploratory lifelong learning, research and professional skills and attitudes.

Ones have enhanced knowledge through combining and using computer science (CS) principles such as computer programming, 3D graphics and information visualization techniques [33, 34]; cognitive abilities (CA) concepts like reading, writing and spatial thinking skills [30], [33]; and k-12 curricular scientific knowledge (k-12CSK) fundamentals related to mathematical concepts like positive and negative numbers, Cartesian coordinate system and geometric shapes for producing digital content[7-11], bringing about within long-term observation citizens' digital literacy and inclusion with sustainability in both educational and professional life.

This kind of educational project roadmap can be adapted to several socio-economic contexts. It is able to stimulate individuals' producing digital content with support of accessible and advanced web3D based technology, which can be affordable for both students under economic disadvantage and schools with low budget. In addition, this type of learning project can contribute for reflections on how to developing effective teaching and learning practices, addressing the challenges of broadening participation in computer science [37] and expanding immersive education possibilities at k-12 education levels [38] .

Related Work

There has been a decrease in virtual reality (VR) and information visualization technology costs [23] and an increase on developing VR applications for art, design, and sciences [23, 24], including the use of 3D interactive techniques for enhancing students' digital literacy and scientific knowledge at k-12 levels [2, 3], [25-28], [35], [38].

Educational projects such as [26, 27] have used 3D graphical interfaces to stimulate primary students' learning. The educational work in [27] has inspired sixth grade students create stories and enhance digital art skills using software modeling tools for producing 3D models and exporting them to accessible web3D-based file formats related to Virtual Reality Modeling language (VRML= wrl.) and Extensible 3D Language (X3D = .x3d).

However, through stimulating individuals' hands-on web3D based scripting languages such as X3D for producing content can highlight the idea of bringing the understanding to the K-12 level students about what is in behind a 3D interface and its interrelation with k-12 curricular topics as English language, geometry, arts and math.

Conceptual Knowledge

A combination of cognitive sciences, action research, immersive education and web3D-based technology forms a conceptual knowledge that has supported this work.

According to Ronchi in [12] cognitive sciences' studies about an individual's knowledge building process that encompass information transmission and learning mechanisms utilized by human cognitive apparatus have addressed the approach of "learning by doing" with support of digital technologies. Learning by doing is an approach that we use when learning, for instance, a skill. In other words is "the perceptive-motory method, which involves watching, touching, testing, and then imitating or retesting." It is the method by which a child initially experiences and learns until artificially develops the symbolic-reconstructive method. The symbolic-reconstructive method encompasses "decoding symbols (language) and then mentally "rebuilding" the transmitted concept." This method is associated with learning processes, for example, reading, understanding, reflecting, reasoning, induction, deduction and involves processing information being aware and conscious. However, the perceptive-motory method or the primary learning mechanism "can only be activated, if the object belongs to the physical world". Due to "the "undo" option, the same trial and error approach entered the world of software", enables ones to use the learning by doing method."

In this context, virtual reality (VR) represents the tool that provides connecting the perceptive-motory system to nonphysical objects - virtual digital objects. VR technology has allowed individuals materializing a mathematical space in which they touch a molecule and modify its structure such as exploring a mechanism or human body from inside. Considering the process of "transmitting knowledge: if the knowledge consists of a group of concepts with structure (links and relationships), its transmission via conventional media implies a sequential single-channel protocol that involves the disassembly of the structure into nodes, relationships and constrains." In contrast, knowledge transmission via hypermedia and or VR interactive techniques can bring about "interactive transmission of structured knowledge spread across many channels along with the full set of links and relationships" [12].

An empirical example interrelating individuals' cognitive abilities such as spatial thinking, reading and writing, learning by doing, VR and information visualization techniques as well as k-12 curricular topics such as math and geometry was carried out in the context of HCI and production of a 3D space content at the primary school object of this article. It supported an action/teacher researcher attempting to enhance the processes involving participatory and interactive teaching and learning actions and can be visualized in figure-1.

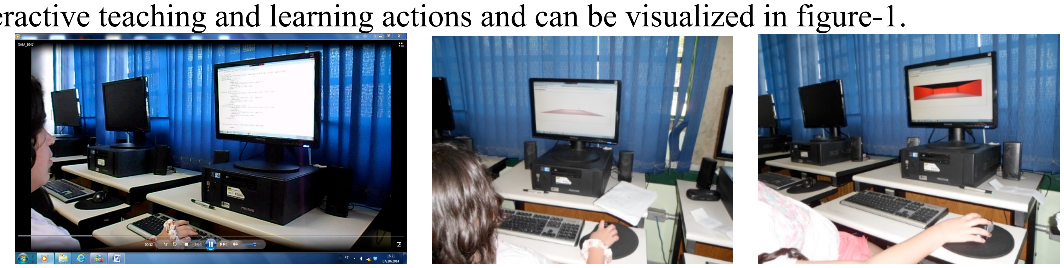


Figure 1. A student within a process of learning by doing via producing 3D content through applying computer programming skills and cognitive abilities such as reading, writing, attention and spatial thinking based on using the interrelation of cognitive sciences and VR techniques

Action Research

Action research (AR) has as features to be participatory and democratic. It supports a teacher / researcher investigates the impact of her/his intervention and monitor whether it brings about a difference. Hence, AR is socially responsive and takes place in context. The knowledge acquired through AR can serve as base for an educational community enhances teaching and learning practices and policy making [13]. Considering a growing prevalence of 3D digital spaces impact on individuals' lives, for instance, through entertainment, cultural and military industry [3], [12], previous k-12 educational work [3], [5],[25], including a combination between cognitive science studies and VR techniques as mentioned and sowed above, it seems plausible stimulating an increase in learning activities based on the immersive education (IE) concept.

Immersive Education

The concept of IE and its features have formed a flexible learning platform that combines interactive 3D graphics, simulation technology, VR, web cameras and rich digital media with collaborative online course environments and classrooms. IE has given participants a sense of "being there" even when they cannot attend a class. IE has provided individuals with the ability to connect and communicate in a way that greatly enhances a learning experience [14].

For instance, students and educators can develop and share their acquired knowledge through research centers web sites [15], e-mails and blogs such as described in our previous work [8, 9]. Hence, the IE concept supports individuals' experience in and outdoor classroom 'learning by doing' educational activities based on several digital media devices as in figure-2.

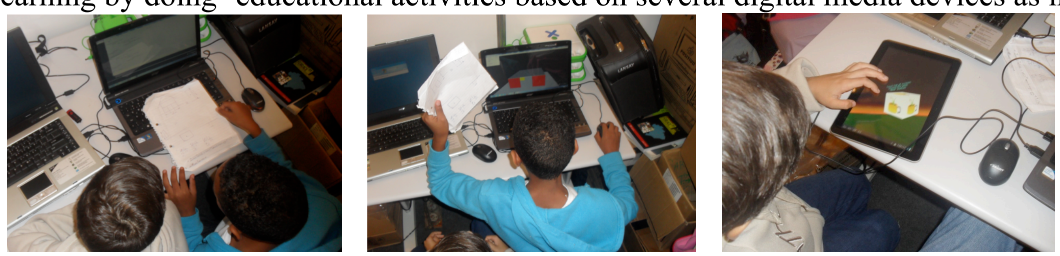


Figure 2. Students in an outside class learning activity, in which they produced and visualized 3D digital spaces with support of combining cognitive skills as reading and writing web3D-based information visualization techniques, during Feira Brasileira de Ciências e Engenharia (Brazilian Fair of Science and Engineering) – FEBRACE [36] at the University of Sao Paulo

Digital Techniques and The X3dom framework

Graphical capabilities of modern browsers, growing accessibility and interoperability of web-based languages as the Extensible Markup Language (XML) that are used to describe and format 2D and 3D digital content have been enhanced [17-19], [33]. Improvements of XML based languages, such as the X3D, which extends VRML capabilities, have allowed non technical individuals to learn 3D graphics concepts, design, create and present 3D digital content standalone through a specific 3D browser or embed into a web page with support of Hypertext Markup Language (HTML) [17]. HTML development is on its 5 version (HTML5). Its syntax conformance is compatible with XML [20]. HTML5 has new syntactic features such as <video>, <audio> and <canvas> elements, and the integration of scalable vector graphics (SVG) content (that replaces the uses of generic <object> tags) and MathML for mathematical formulas [21].

Research and development related to 3D graphics and HTML5 interoperability on modern web browsers have brought about the creation of X3Dom. It is an experimental open-source framework and runtime that has supported a discussion in the Web3D and W3C communities on how an integration of HTML5 and declarative 3D content could look like. It fulfills HTML5 specification for declarative 3D content and allows including X3D elements as part of any HTML5 DOM tree [16]. Based on such HTML5 and X3D interoperability, the X3dom framework has encompassed the ability to visualize and manipulate spatial content in real-time, which seems to be the next key-enabler for a wide number of application areas [22].

Web3D based Techniques and Digital Materials in this Work

Contemporary web browsers such as Firefox™ and Google Chrome™ have allowed accessibility to HTML5 and X3dom for stimulating students' exploratory learning activities through using the X3Dom framework to understand and apply 3D graphics concepts such as computer programming, design, creating and visualizing content in real time. This experimental hands-on work has applied low cost digital image editors such as MS Paint and GIMP software. It includes text editors such as an ordinary notepad. For further digital knowledge enhancements and building more complex code related to computer programming, it is utilized Notepad++™, which is an open source editor that supports several programming languages [29] as in figure-3.

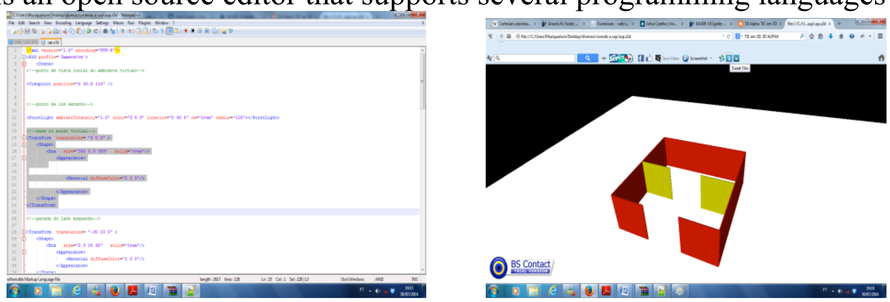


Figure 3. On the left, a demo programming code edited in the Notepad++. On the right, its symbolic representation through using Notepad++ (run) button, which supports a real time integration of this software with a web-based information and visualization tool

Work Context and Strategies

Since 2002, author1 has been an English language teacher and an information and communication facilitator at Ernani Silva Bruno Primary School and coordinated this project in a suburb of Sao Paulo city metropolitan area. It is an after-school project implemented for introducing web3D-based technology to twelve primary students, six boys and six girls age 9 up to 12 years old from May to December 2012 [8], [15], attempting to develop an equity learning process as in [37]. Since 2013, the meetings have occurred during an author1's studying time, once a week, for about 50 minutes, in the second semester of each year. Students have joined to this project in a volunteer way.

This educational project has extended a long-term interactive knowledge-based learning framework process of using advanced information visualization technologies (AIVT) for stimulating students understand and apply such knowledge in combination with curricular topics at k-12 levels [9-11]. Individuals have applied computer programming for producing digital content and visualizing data in real time in tandem with graphical capabilities of modern web browsers, based on Declarative 3D for the Web Architecture W3C Community Group work that has formed declarative ways of incorporating 3D graphics directly into HTML to enable its use on any Web page [18].

The strategy of stimulating students' computer programming skills has been a mood of reflecting with children and showing them accessible and practical possibilities of using English language knowledge in an effective way beyond the classroom and homework activities. It includes, promoting individuals' more complex uses of digital devices and AIVT techniques. It has been a way of inspiring ones' thoughts about the importance of writing and reading with attention via observing the upper and lower cases of a given scripting language for programming a computer [9, 10]. We believe that attention as a cognitive ability [30] can be trained through problem solving activities such as doing computer programming for symbolic representing and visualizing a given and or imaginary content as in figure-3 and the use case section that follows.

A Human Computer Interaction Use Case

This HCI use case is based on author1's direct observation of a student's attitudes, cognitive actions, and digital and scientific knowledge application through designing, programming and visualizing a 3D digital space representing a room with five walls in figure-1. It was a moment of HCI registered with a video camera with support of action research and HCI features related to data collection such as [13, 31].

The idea was stimulating her 3D graphics and spatial thinking knowledge referent to the rotation and translation fields through moving and positioning digital objects while building a 3D virtual world across using the X3Dom framework such as in figure-1. This hands-on learning activity process brought about stimulating her computer programming and spatial thinking skills based on math concepts such positive and negative numbers and Cartesian coordinate systems.

Her applied knowledge indicates a qualitative evidence of the effectiveness of this kind of immersive and hands-on exploratory learning by doing approach. According to a video record, when author1asked her if she had learned the Cartesian coordinate system concept during her regular math class. She said that did not learn this topic in a math class. But she learned that through combining CS, CA, AIVT and k-12CSK concepts during this afterschool project.

Final Considerations

We have presented an action research project which has used the X3Dom framework, a web3D-based technology, for stimulating students producing 3D digital content and engaging in exploratory learning attitudes since K-12 Levels. This educational project, in its previous [9-11] and current learning activities, has stimulated students' cognitive and digital competency enhancements. And inspired students' lifelong learning attitudes related to reading, writing and publishing digital content in blogs and practicing computer programming at school and home.

Several examples such as the one in the case study section describing a student hands-on learning activity have highlighted the ideas and concepts presented during this paper. She was at the fourth grade in 2012 when she started in this project. She developed the 3D digital space in figure-1at the end of 2013, showing an increase in her awareness about the described interrelation among CS, CA, k-12CSK in the introduction section.

Other qualitative results are that some students developed blogs inserting X3Dom code on it and symbolic representing a virtual gallery similar to figure-2. Hence, a student reported that after this project HCI, he accessed SketchUp™ software and modeled a 3D soccer stadium at home, porting his stadium's model to a mobile phone. At the beginning of 2013he showed it to his mates and author1, one week before the FEBRACE at USP. He also said that this project learning experience impacted in improving communication with his father related to digital technology knowledge.

However, it keeps the challenge of motivating and sustaining students to be engaged in doing interdisciplinary research and complex human computer interaction tasks permanently. For instance, from the 12 volunteer students that started this project in 2012, there are 2 participating in it, and a new one started in the second semester of 2014.

Athour1's reflection about the necessity of inspiring ones' motivation and mental model transformation indicates that presenting this kind of immersive education and advanced digital technology to students, mainly, when they are able to start reading with moderate or great autonomy at the third or fourth grade can be essential for stimulating their digital and scientific knowledge enhancements as, for instance, one of the students in our previous work [10]. Another example, of an immersive educational work that explores this kind of IE concept is in [38]. In addition, this work has addressed international community's concerns about how to stimulate individuals to be able of doing complex digital tasks related to the field of computer science, such as computer programming, after ones leaving k-12 education and going to the market for working and keep studying [1], [31], [32], [37].

Some students who participated in our previous work carried out at the mentioned primary school are now at college [9, 10]. Two of them have engaged in the field of computer science. By email, in September 2014, one reported that is finishing his computer science course and has worked enjoying a task of modeling 3D digital spaces through using CAD systems. Another student, who has studied design at college, began his digital skills using VRML at school. After that he asked for a more advanced modeling tool. He was introduced to and learned Blender software. He reported that started appreciating and developing English language skills through reading Blender tutorials. He has kept studying English language formally.

These promising lifelong learning evidences have brought about the challenge and reflection on how to expand the use of the described proceedings and technologies with classes of 35 students at k-12 levels. For the future, the idea is to keep offering HCI to students at k-12 levels and stimulating their cognitive, scientific and digital knowledge enhancements.

Using an interdisciplinary combination among CS, CA, K-12CSK for stimulating individuals' knowledge enhancements has been done with low cost, through applying ordinary computers, web3D technology, computer programming and real time information visualization techniques. It has brought about citizens' digital literacy and inclusion with sustainability.

References and Notes:

1. DCMS - Department for Culture, Media and Sport, The Government's re-sponse to Next Gen. Transforming the UK into the world's leading talent hub for the video games and visual effects industries, Department for Culture, Media and Sport, (2011), http://www.dcms.gov.uk/images/publications/Govt-Resp_NextGen_Cm-8226.pdf.

2. Durlach, N. I., Mavor, A. S., Eds.: Virtual reality: scientific and techno-logical challenges NPA, USA, pp. 1-88 (1995).

3. Bainbridge, W. S., Ed.: Online worlds: convergence of the real and the virtual, Springer, London, pp. 1-6, 111-122 (2010).

4. Donelan, J.: Taking the initiative (CGW Issue: Volume: 31 Issue: 10, Oct. (2008), http://www.cgw.com/Publications/CGW/2008/Volume-31-Issue-10-Oct-2008-/Knowledge-and-Career-11-08.aspxa.

5. Youngblut, C.: Educational uses of virtual reality technology, Tech. Report IDA Document D-2128, Institute for Defense Analyses, Alexandria, Va., (1998), http://www.hitl.washington.edu/scivw/publications.html.

6. Franco, J. F., Telles, E. O.: Using advance web3d based information visualization technology to support an exploratory hands –on workshop for k-12 educators. In: proceedings IATED, EDULEARN14, 6th annual Conference on Education and New Learning Technologies, Barcelona , Spain, on the 7 - 9 of July, pp. 5978 - 5984 (2014)

7. Franco, J. F.: Reflections related to applying web3D-based computer graphics programming and information visualization technologies for stimulating individuals' digital literacy, cognitive skills and sciences knowledge enhancements at K-12 Levels. In: paper presented at ICT 2014/Social Media, 15 – 17, April, City University of Hong Kong, China, (2014), http://www.socialmediaforall.org/program.html.

8. References J. F., Lopes, R. D.: Using X3DOM for promoting students' digital and visual literacy at K-12 education: a use case. In: Proceedings Web3D 2013, ACM, June 20 – 22, San Sebastian, Spain (2013)

9. Franco, J. F., Lopes, R. D.: Developing an interactive knowledge-based learning framework with support of computer graphics and web-based technologies for enhancing individuals' cognition, scientific, learning per-formance and digital literacy competences. In: Computer Graphics, N. Mukai, Ed., Intech, Croatia, chap 13, pp. 229 – 256 (2012), http://www.intechopen.com/books/computer-graphics.

10. Franco, J. F. et al,: Enhancing Individuals' Cognition, Intelligence and Sharing Digital/Web-Based Knowledge Using Virtual Reality and Infor-mation Visualization Techniques and Tools within K-12 Education and its Impact on Democratizing the Society. In: Cognitive and emotional pro-cesses in web-based education: integrating human factors and personalization G. Mourlas, N. Tsianos, P. Germanakos, Eds., IGI, USA, chap XIV, pp. 245-319 (2009).

11. Franco, J. F, Lopes, R D.: Three-dimensional digital environments and computer graphics influencing k-12 individuals' digital literacy develop-ment and lifelong learning. In: Proceedings of The 2nd ACM – SIGGRAPH ASIA 2009, Educators Program, Yokohama, Japan 16-19, December (2009).

12. Ronchi, A. M.: E-culture: cultural content in the digital age, Springer, Germany, pp. 67-68 (2009).

13. Mills, G. E: Action research: a guide for the teacher researcher, Pearson Education, USA, pp. 10-12 (2014).

14. Immersive Education, (2014) http://members.immersiveeducation.org/about.

15. X3dom: X3dom used in a primary school project (2012), http://www.x3dom.org/?p=3050.

16. X3Dom: Instant 3D the HTML way, (2014), http://www.x3dom.org/.

17. D. Brutzman, L. Daly: Extensible 3D graphics for web authors, Morgan Kaufman, China (2007).

18. Jankowski, J.: Writing effective use cases for the declarative 3D for the web architecture, DEC3D, (2012), HTTP://CEUR-WS.ORG/VOL-869/DEC3D2012_04.PDF.

19. Ashbacher, C.: XML in 24 hours, SAMS, USA, pp. 393-407 (2000).

20. W3C: HTML5 differences from HTML4 editor's Draft (2012), http://dev.w3.org/html5/html4-differences/.

21. HTML5: (2014), http://en.wikipedia.org/wiki/HTML_5.

22. Behr, J. et al.: X3DOM: a DOM-based HTML5/X3D integration model. In: Web3D 2009, Darmstadt, Germany, June 16 – 17, pp. 127-135 (2009).

23. La Viola, J. J., Keefe, D. F.: 3D spatial interaction: applications for art, de-sign, and science. In: Proceeding SIGGRAPH '11 ACM SIGGRAPH 2011 Courses, Article nº 1, ACM, New York, pp. 75p. (2011).

24. Nanu, A. et al.: The Romanian folk costume as a component of the country brand. Use of modern methods of education based on virtual reality. In: proceedings IATED, EDULEARN14, 6th annual Conference on Education and New Learning Technologies, Barcelona , Spain, on the 7 - 9 of July, pp. 2753 - 2762 (2014).

25. Roussou, M.: Learning by doing and Learning through play: An Exploration of interactivity in virtual Environments for children. In: ACM Computers in Entertainment, Volume 2, Number 1, January 2004, Article 1, pp. 1-23 (2004).

26. Bouta, H., Retails, S. Enhancing primary school children collaborative learning experiences in maths via a 3D virtual environment. In: Education and Information Technologies December 2013, Springer, Volume 18, Is-sue 4, pp 571-596 (2013).

27. Coelho, A.: 3D Alpha: Generic 3D and VRML/X3D applications in elementary education (2012). https://unl-pt.academia.edu/ArturCoelho/Papers.

28. Foster, A. EAGER: US Ignite: A cloud enabled virtual reality based pedagogical ecosystem for green energy and environmental engineering education, (2013), http://drexel.edu/soe/faculty-research/faculty/Foster-Aroutis/.

29. Notepad++ (2014), http://www.2download.co/notepad.html?gclid=CMTGl56c3bYCFUFo4AodJHEAgQ.

30. Sharp, H., Rogers, Y., Preece, J.: Interaction designing: beyond human computer interaction, 2nd edition, Wiley, United Kingdom, pp. 99-131 (2007).

31. Codecademy: (2014), http://www.codecademy.com/pt-BR.

32. Obama, B.: President Obama asks America to learn computer science, (2013), https://www.youtube.com/watch?v=6XvmhE1J9PY.

33. Chen, C.: Information Visualization, 2nd edition, Springer, United king-dom, pp. 173-210 (2006).

34. Papert, S.: Mindstorms: children, computers and powerful ideas, Basic Books, USA, pp. 95-119 (1993).

35. Proceedings of the 8th Immersive Education Summit (iED 2013), 3-6 June (2013), Boston, MA.ISSN 2325-4041. http://JiED.org/proceedings/iED_2013.

36. FEBRACE, (2014), http://febrace.org.br/.

37. Margolis, J., Goode, J., Chapman, G., Ryoo, J. J.: Broadening Participation. Viewpoints. Communications of the ACM, USA, July, vol. 57, nº7, (2014).

38. Immersive education: Historic Boston school expands Immersive Education (2014), http://campaign.r20.constantcontact.com/render?ca=11b021b0-0943-4c5d-9498-638467433fb1&c=a4d527b0-4dbc-11e3-9ce6-d4ae5292c40b&ch=a65c15d0-4dbc-11e3-9cfe-d4ae5292c40b.

Acknowledgments: I would like to thank the students that have engaged in this web3D-based learning project development process through their content production of 3D digital spaces such as in students' blogs (http://marianamss.blogspot.com.br/; (http://856585.blogspot.com.br/). It includes the administrative and pedagogic staff from the Ernani Silva Bruno Primary School and research team of the Laboratory of Integrated Systems of the Polytechnic School at USP.

Paper

Mining and Visualizing Trends from Educational Systems using Linked Data

Authors: S. Softic[1,*], B. Taraghi[1], M. Ebner[1]

Affiliations:

[1] Graz University of Technology

*Correspondence to: selver.softic@tugraz.at

Abstract: This work introduces a case study on usage of semantic context modelling and creation of Linked Data from logs in educational systems like a Personal Learning Environment (PLE) with purpose on improvements in generally with respect to social and semantic analysis of the parameters on user and activity centric level [3]. Sample case study demonstrates the usage of semantic modelling of the activity context using adequate domain specific ontologies and semantic technologies and visualization of such data as result of analysis of such modelled data represented in the form of Linked Data. This approach implies the easy interfacing and extensibility on machine or human level offering fast insight on statistical trends.

One Sentence Summary: This work introduces a case study on usage of semantic context modelling and creation of Linked Data for mining trends from logs in educational systems.

1. Introduction

Modern learning environments, besides learning resources provided by the educational institution, aim at integration of popular internet services that might be of interest of learners like: Google Hangout, Facebook, YouTube, Newsgroups, Twitter, Slideshare just to name some of them. Maintaining such platforms is intensively changing process demanding from maintainers to actively adapt their systems to the learner needs. Nowadays, learners are expecting focused and simple platforms helping them to organize their learning process. Learners don't want to waste their time on information and actions which could disturb or prolong their learning. Therefore user adaptively is a strong impact on acceptance of such platforms and should be matter of continuous improvement.

Cumulated system monitoring data (e.g. logs) of such environments offers new opportunities for optimization [8]. Such data can contribute the better personalization and adaptation of the learning process but also improve the design of learning interfaces.

Main contribution of the paper is a case study done with the logs from PLE at Graz University of Technology presenting approach using Linked Data to mine the usage trends from PLE. The idea behind this effort is aiming at gaining insights useful for optimization of PLE [4], and adapting them to the learners, by using more personalization, e.g. through recommendation of interesting learning widgets.

2. Related Work

This section report shortly about most relevant related work regarding PLE (at Graz University of Technology), and semantic technologies used in this work.

2.1 PLE at Graz University of Technology

The main idea of PLE at Graz University of Technology (http://ple.tugraz.at) is to integrate existing university services, and resources [2], with services and resources from the World Wide Web in one platform and in a personalized way [2]. The TU Graz PLE contains widgets [14 - 16] that represent the resources and services integrated from the World Wide Web. Web today provides lots of different services; each can be used as supplement for teaching and learning. The PLE has been redesigned in 2011, using metaphors such as apps and spaces for a better learner-centered application and higher attractiveness [1, 13]. In order to enhance PLE in general and improve the usability as well as usefulness of each individual widget a tracking module was implemented by prior work [17]. Different works outlined the importance of tracking activity data in Learning Management Systems [9, 18]. None of them addressed the issue of intelligently structuring monitoring data in context and processing it to provide a flexible interface that ensures maximum benefit from collected information.

2.2 Semantic Modeling of Activities in PLE

The Semantic Web standards like RDF (http://www.w3.org/RDF) and SPARQL (http://www.w3.org/TR/rdf-sparql-query/) enable data to be and for interchange and queried as graphs. Data schema is usually projected on specific knowledge domain using adequate ontologies. This approach has been fairly successful used to generate correct interpretation of web tables [5] to advance the learning process [7, 3] as well to support the controlled knowledge generation in E-learning environments [12]. This potential was also recognized by resent research in IntelLEO Project (http://intelleo.eu). IntelLEO delivered an ontology framework where *Activities Ontology* (http://www.intelleo.eu/ontologies/activities/spec/) is used to model learning activities and events related to them. Due to the relatedness to the problem that is addressed by this work these ontologies have been used to model the context of analytic data collected from PLE logs.

3. Approach for Mining Usage Logs

Presented approach is based on transforming collected data from PLE logs into instances of Activities Ontology. This process produces as output Linked Data graphs query able by SPARQL standard query language. The SPARQL is applied to query the Linked Data and mine the output for analytic visualizations (see Figure 1). The overall goal of this process is summarization, visualizations and evaluation of statistic data that enable the PLE optimization, in interface design and adaptation of content of PLE to the learner. This approach is inspired by the examples from current research in the area of Self-regulated Learners (SRL) [3, 11].

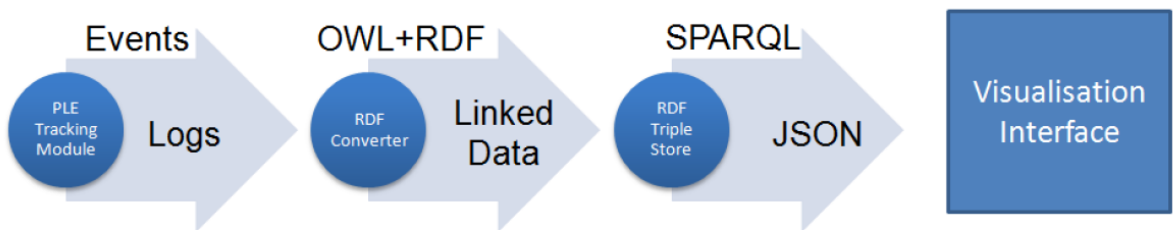


Figure 1. Mining pipe line for PLE usage logs.

3.1 Dataset

Data used in the case study originates from Personal Learning Environment (PLE) (https://ple.tugraz.at) developed for the needs of Graz University of Technology which serves currently more than 4000 users. The data was collected during two years period in order to generate analytics reports with visualization support for overall usage and process view on our environment following the research trends of previous years [10, 6].

3.2 Modeling Usage Logs

The main precondition for meaningful mining of usage trends is choice of appropriate data model since RDF offers only the framework how structure and link data. This task concerns mostly the choice of the right vocabulary or ontology. Activities Ontology offers a vocabulary to represent different activities and events related to them inside of a learning environment with possibility to describe and reference the environment (in this case PLE) where these activities occur. Formulation (in Figure 2.) depicts an instance of usage **ao:Logging** instance. This excerpt comes from the tracking module. Such data is stored in a memory RDF Store (Graph Database for Linked Data) with SPARQL Endpoint (interface where Linked Data can be queried).This sample instance reflects that a usage **ao:Logging** event occurred at certain time point inside the learning widget named *LatexFormulaToPngWidget* as **ao:Enviroment**. As shown in this example vocabularies and ontologies which suit well to specific case enriches the analytic process, in a very compact manner, with a high level of expressiveness.

```
@prefix ao: <http://intelleo.eu/ontologies/activities/ns/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .

<http://ple.tugraz.at/ns/events/log/#7912>
    rdf:type ao:Logging;
    ao: occursIn <https://ple.tugraz.at/ns/widgets/#LatexFormulaToPngWidget>;
    ao:timestamp "2012-10-04T07:52:52" .

<https://ple.tugraz.at/ns/widgets/#LatexFormulaToPngWidget>
    rdf:type ao:Enivironment;
    rdfs:label "LaTeXFormulaPNG Converter" .
```

Figure 2. Sample model of a usage log in N3 notation.

3.3 Querying of Usage Logs

Usage logs data presented as Linked Data graph are query able using SPARQL. In this way we are able to answer the questions like "Show me the top 15 used widgets?". Figure 3. represents exactly this question stated in the manner of SPARQL syntax.

```
PREFIX ao: <http://intelleo.eu/ontologies/activities/ns/> .
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#> .

SELECT ?widgetname ?date COUNT(DISTINCT ?widgetname) WHERE
{
 ?x rdf:type ao:Logging;
    ao:occursIn ?widget;
    ao:timestamp ?date.

 ?widget rdf:type ao:Environment;
    rdfs:label ?widgetname.
}
LIMIT 15
```

Figure 3. Querying the intensity of usage of top 15 widgets in PLE.

4. Preliminary Results, Conclusion and Outlook

As preliminary result presented approach allows mining the trends of PLE widgets usage overall time periods like presented in Figure 4. This violin graph depicts the visual answer of the query from Figure 3. Also the intensity shows that as expected that most activity on widgets happens at the beginning when PLE is presented in introductory lectures to the newcomers and freshmen and at the end of academic terms when most of the students prepare for examinations.

Advantages of Linked Data approach is usage of standardized web technologies which are scalable and flexible regarding the changes of representation structure of data.

SPARQL as query language which operates over the Linked Data graphs of usage logs offers much flexibility regarding the generation of results that should be visualized in end instance. It also allows on-demand statistical accumulations that can be used in the future as basic stats for recommendation of new widgets in the PLE or similar tasks.

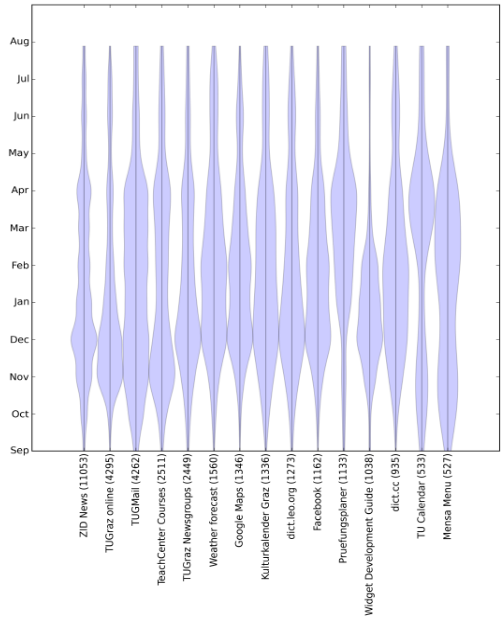


Figure 4. Visualizing the usage widget wise for top 15 widgets for year 2012.

References and Notes:

1. Ebner, M., Scerbakov, N., Taraghi, B., Nagler, W., Kamrat, I.: Teaching and learning in higher education - an integral approach. Society for Information Technology and Teacher Education International Conference pp. 428-436 (2010)
2. Ebner, M., Taraghi, B.: Personal learning environment for higher education-a First prototype. Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications pp. 1158-1166 (2010)
3. Jeremic, Z., Jovanovic, J., Galiasevic, D.: Personal learning environments on the social semantic web. Semantic Web (2012)
4. Mazza, R., Milani, C.: Exploring usage analysis in learning systems: Gaining insights from visualisations. In: Workshop on Usage Analysis in Learning Systems, Proceedings of Artificial Intelligence in Education. Amsterdam (2005)
5. Mulwad, V., Finin, T., Syed, Z., Joshi, A.: Using linked data to interpret tables. In: Hartig, O., Harth, A., Sequeda, J. (eds.) COLD. CEUR Workshop Proceedings, vol. 665. CEUR-WS.org (2010), http://dblp.uni-trier.de/db/conf/semweb/cold2010.html#MulwadFSJ10a
6. Pardo, A., Kloos, C.D.: Stepping out of the box: towards analytics outside the learning management system. In: Proceedings of the 1st International Conference on Learning Analytics and Knowledge. pp. 163-167. LAK '11, ACM, New York, NY, USA (2011), http://doi.acm.org/10.1145/2090116.2090142
7. Prinsloo, P., Slade, S., Galpin, F.: Learning analytics: challenges, paradoxes and opportunities for mega open distance learning institutions. In: Proceedings of the 2nd

International Conference on Learning Analytics and Knowledge. pp. 130-133. LAK '12, ACM, New York, NY, USA (2012), http://doi.acm.org/10.1145/2330601.2330635

8. Rosen, D., Miagkikh, V., Suthers, D.: Social and semantic network analysis of chat logs. In: Proceedings of the 1st International Conference on Learning Analytics and Knowledge. pp. 134-139. LAK '11, ACM, New York, NY, USA (2011), http://doi.acm.org/10.1145/2090116.2090137
9. Santos, J.L., Govaerts, S., Verbert, K., Duval, E.: Goal-oriented visualizations of activity tracking: a case study with engineering students. In: Proceedings of the 2nd International Conference on Learning Analytics and Knowledge. pp. 143-152. LAK'12, ACM, New York, NY, USA (2012), http://doi.acm.org/10.1145/2330601.2330639
10. Santos Odriozola, J.L., Verbert, K., Govaerts, S., Duval, E.: Visualizing PLE usage. In: Proceedings of EFEPLE11 1st Workshop on Exploring the Fitness and Evolvability of Personal Learning Environments,. pp. 34-38. CEUR WS (Aug 2011), https://lirias.kuleuven.be/handle/123456789/322006
11. Siadaty, M., Jovanovic, J., Pata, K., Holocher-Ertl, T., Gasevic, D., Milikic, N.: A semantic web-enabled tool for self-regulated learning in the workplace. In: ICALT. pp. 66-70. IEEE Computer Society (2011), http://dblp.uni-trier.de/db/conf/icalt/icalt2011.html#SiadatyJPHGM11
12. Softic, S., Taraghi, B., Halb, W.: Weaving social e-learning platforms into the web of linked data. Proceedings of I-SEMANTICS pp. 559-567 (2009)
13. Taraghi, B., Ebner, M., Clemens, K.: Personal learning environment – generation 2.0 pp. 1828-1835 (2012)
14. Taraghi, B., Ebner, M., Schaffert, S.: Personal learning environments for higher education: A mashup based widget concept. Proceedings of the Second International Workshop on Mashup Personal Learning Environments (MUPPLE 2009), Nice, France (2009)
15. Taraghi, B., Ebner, M., Till, G., Mühlburger, H.: Personal learning environment - a conceptual study. International Conference on Interactive Computer Aided Learning pp. 25-30 (2009)
16. Taraghi, B., Mühlburger, H., Ebner, M., Nagler, W.: Will personal learning environments become ubiquitous through the use of widgets? Proceedings of I-KNOW, 329-335 (2009)
17. Taraghi, B., Stickel, C., Ebner, M.: Survival of the fittest - utilization of natural selection mechanisms for improving ple. Proceedings of the first Workshop on Exploring the Fitness and Evolvability of Personal Learning Environments pp. 4-9 (2011)
18. Verbert, K., Drachsler, H., Manouselis, N., Wolpers, M., Vuorikari, R., Duval, E.: Dataset-driven research for improving recommender systems for learning. In: Proceedings of the 1st International Conference on Learning Analytics and Knowledge. pp. 44-53. LAK '11, ACM, New York, NY, USA (2011), http://doi.acm.org/10.1145/2090116.2090122