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Selected Papers Book

A number of selected papers presented at CSEDU 2014 will be published by Springer-Verlag in a CCIS Series book. This selection will be done by the Conference Chair and Program Co-chairs, among the papers actually presented at the conference, based on a rigorous review by the CSEDU 2014 Program Committee members.

FOREWORD

This book contains the proceedings of the 6th International Conference on Computer Supported Education (CSEDU 2014) which was organized and sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC). This conference was held in Cooperation with the Association for Computing Machinery - Special Interest Group for Information Technology Education, European Council for Business Education (ECBE) and Association des Technologies de l'Information pour l'Education et la Formation (ATIEF). The conference was also technically co-sponsored by IEEE Education Society - Capitulo Español and SPEE (Sociedade Portuguesa para a Educação em Engenharia).

CSEDU has become an annual meeting place for presenting and discussing learning paradigms, best practices and case studies that concern innovative computer-supported learning strategies, institutional policies on technology-enhanced learning including learning from distance, supported by technology. The Web is currently a preferred medium for distance learning and the learning practice in this context is usually referred to as e-learning or technology-enhanced learning. CSEDU 2014 provided an overview of the state of the art in technology-enhanced learning and outlined upcoming trends and promoting discussions about the educational potential of new learning technologies in the academic and corporate world.

This conference brought together researchers and practitioners interested in methodologies and applications related to the education field. It had five main topic areas, covering different aspects of Computer Supported Education, including "Information Technologies Supporting Learning", "Learning/Teaching Methodologies and Assessment", "Social Context and Learning Environments", "Domain Applications and Case Studies" and "Ubiquitous Learning". We believe these proceedings demonstrate new and innovative solutions, and highlight technical problems in each field that are challenging and worthwhile.

CSEDU 2014 received 242 paper submissions from 57 countries in all continents. A double-blind review process was enforced, with the help of the 277 experts who were members of the conference program committee, all of them internationally recognized in one of the main conference topic areas. Only 32 papers were selected to be published and presented as full papers, (i.e., completed work, 12 pages in proceedings, 30-minute oral presentations) for a 13% acceptance rate. Another 69 papers, describing work-in-progress, were selected as short papers for 20' oral presentation and 71 papers were presented as posters. All accepted papers represent a high level of quality, which we intend to maintain and reinforce in the next edition of this conference.

The high quality of the CSEDU 2014 programme was enhanced by four keynote lectures, delivered by experts in their fields, including (alphabetically): Erik de Graaff (Aalborg University, Denmark), José Carlos Lourenço Quadrado (ISEL - Lisbon Superior Engineering Institute, Portugal and IFEES - International Federation of Engineering Education Societies, United States), Larissa Fradkin (London South Bank University, Brunel University and Sound Mathematics Ltd., United Kingdom) and Steve Wheeler (Plymouth Institute of Education, Plymouth University, United Kingdom).

For the sixth edition of the conference we extended and ensured appropriate indexing of the proceedings of CSEDU including Thomson Reuters Conference Proceedings Citation Index, INSPEC, DBLP, EI and Scopus. Besides the proceedings edited by SCITEPRESS, a short list of papers presented at the conference will be selected so that revised and extended versions of these papers will be published by Springer-Verlag in a CCIS Series book. Furthermore, all presented papers will soon be available at the SCITEPRESS digital library.

The best contributions to the conference and the best student submissions were distinguished with awards based on the best combined marks of paper reviewing, as assessed by the Program Committee, and the quality of the presentation, as assessed by session chairs at the conference venue.

The conference was complemented with a special session, focusing on Well-being Literacy; named Special Session on Well-being Literacy through Multimedia Education for Vulnerable Populations - WeLL 2014.

Building an interesting and successful program for the conference required the dedicated effort of many people. Firstly, we must thank the authors, whose research and development efforts are recorded here. Secondly, we thank the members of the program committee and additional reviewers for their diligence and expert reviewing. We also wish to include here a word of appreciation for the excellent organization provided by the conference secretariat, from INSTICC, which has smoothly and efficiently prepared the most appropriate environment for a productive meeting and scientific networking. Last but not least, we thank the invited speakers for their invaluable contribution and for taking the time to synthesize and deliver their talks.

Markus Helfert
Dublin City University, Ireland

Susan Zvacek
Fort Hays State University, U.S.A.

Maria Teresa Restivo
FEUP, Portugal

James Uhomoibhi
University of Ulster, U.K.

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INVITED SPEAKERS

KEYNOTE SPEAKERS

Computer Supported Education
The Human Factor

José Carlos Lourenço Quadrado
ISEL - Lisbon Superior Engineering Institute, Portugal
IFEES - International Federation of Engineering Education Societies, U.S.A.

Abstract: Within the Computer Supported Education (CSE) there are three interesting trends observed.
The first one is the conscience that the technical specialisms are becoming increasingly important. New technologies and the emergence of Mobile, Cloud, Continuous Integration & Deployment allow educators with practical hands-on knowledge and experience to be decisive for the success of CSE projects.
On the other hand, it has changed the way we work together with each other. The necessity to have agile replies to the demands of the education stakeholders, to communicate and take responsibility, demands the critical thinking, the exchange of information and the flexibility being more and more the decisive success factors. These stakeholders are increasing creating a CSE team that consists of individuals more than ever with their own specialty and own drivers.
In addition, the time-to-market of the technology is getting shorter and is strongly dependent on the costs in the current economic climate.
All three trends converge to the manager. As a result, it is noticeable that you have to demonstrate the added value of your part in the CSE team, you must make results visible and under high pressure. How do you do that? Why is man such an important factor? What do you do with the man in your team? How do you put people in their strength and you create a work environment in which everyone comes into its own?

BRIEF BIOGRAPHY

José Carlos Quadrado is the full professor with tenure of electrical machines in the electrical engineering and automation department of the Instituto Superior de Engenharia de Lisboa (ISEL), Portugal.

Currently he holds the position of President of ISEL since 2006.

He has a BSc in Energy and Power Systems, a diploma degree in Electrical Engineering, Automation and Industrial Electronics from ISEL, a MSc and a Doctor degree in Electrical Engineering and Computers from Lisbon Technical University. He also holds the Habilitation degree (Aggregation) in Electrical Engineering from Beira Interior University.

Holds the position of President of the International Federation of Engineering Education Societies (IFEES) and the position of immediate-past president of the Ibero-American Engineering Education Association (ASIBEI), and he is also the immediate past vice-President of the European Society for Engineering Education (SEFI). Former member of the National Bologna Expert Group, he leads the Portuguese Observatory on European and Latin-American University management strategy best practices and the national association of engineering rectors and deans.

Being a member and senior member of several engineering societies and engineering education societies in several continents, he is also a visiting professor in several universities around the world and board member of technological societies.

He holds over 100 international publications (including journals and chapters of books), several patents and some international technical prizes and scholarships, and also held the position of editor and editor-in-chief in some journals. Up to now he has also developed several international engineering projects in the fields of renewable energy, fuel cells, electrical vehicles and intelligent control.

Digital Age Learning
The Changing Face of Online Education

Steve Wheeler
Plymouth Institute of Education, Plymouth University, U.K.

EXTENDED ABSTRACT

Online education was once quite simple. As a new form of distance education, it bridged the gap between those who could reach formal education and those, for whatever reason, who could not. Many institutions invested in web delivery as a primary means of engaging remote students, and a whole discourse rose up around the idea of 'online education.' It was a radical departure from the traditional correspondence courses, because it enabled instantaneous communication and feedback between students and their teachers, and allowed synchronous as well as asynchronous delivery of content. Video and live chat soon because desirable, and even essential facets of the online learning strategy. Content delivery was controlled by the experts through Learning Management Systems, and discussions were conducted via e-mail and bulletin boards. There was talk of the Virtual University, but it never really materialised. Instead, many universities adopted a blended (earlier referred to as a dual mode) delivery of their courses, which involved all of the above techniques, and a mix of other face-to-face and paper based activities. The online delivery model became a stable, reliable method for distance education for millions of students around the globe.

Then came the advent of Web 2.0 and social media and things changed, boundaries blurred and the pace of change accelerated. The rapid development of platforms and services that enabled users to both upload and download content was a departure from the previous, 'sticky' and content led approach of Web 1.0. Suddenly, in the age of the Social Web, user generated content was high profile and ubiquitous. Students began to share their own content through blogs, wikis, podcasts and videos. Platforms such as YouTube, WordPress, Blogger and Wikipedia became the first ports of call, and the user statistics grew exponentially. This was perplexing for many established online course providers. It was perplexing because they were no longer the sole arbiters of 'knowledge' and no longer held the exclusive right of mediators of learning. Many academics questioned the veracity of content that was created by 'amateurs', and many rejected that notion that knowledge could be generated, shared and repurposed freely. Issues of copyright, intellectual property and provenance became uppermost in the minds of teachers and lecturers. Many questions and much soul searching resulted:

In today’s digital age, are Learning Management Systems still required, and is e-mail now increasingly anachronistic? Students now connect on social media tools such as Facebook and Twitter and converse through mobile text. They generate their own content on a regular basis and act as the nodes of their own production. Increasingly informal collaborating comes naturally through the new tools and technologies that constitute their personal learning environments. Add to this mix the meteoric success of Massive Online Open Courses and Flipped Classrooms, the popularity of online social games and prospect of new, emerging technologies such as augmented reality and wearable systems, and we continue to question the future of our current online educational provision. Is online learning now so common place and accessible that anyone can do it? Are we reaching the point in the development of technology that we are now in danger of repeating the mistakes we made when correspondence courses led to the ignominy of 'diploma mills' and ill reputed, fake degrees? What would we need to put into place to prevent this from happening in today's knowledge economy?

In this presentation I will address many of the above questions and offer my personal views on the future of online education in the Web 2.0 digital age. I will pose several questions including: What is

digital learning? How can teachers and students harness the power of tools and technologies for formal learning? What is the changing nature of knowledge? What will be the future of education, in the light of the radical changes and emerging technology? Ultimately, we will discuss issues that will impact upon all teachers and educators in the coming years: What will the next few years hold for online education? What will be the new reality for learning, knowledge and ultimately, human intelligence? Are learner expectations unfulfilled by the current provision of traditional educational institutions? How much will the roles of teachers be required to change? What new theories and practices will we need to develop to stay relevant in an increasingly technological world where the learner is taking control?

BRIEF BIOGRAPHY

Steve Wheeler is Associate Professor of Learning Technologies at Plymouth University, in South West England. Originally trained as a psychologist, he has spent his entire career working in media, technology and learning, predominantly in nurse education (NHS 1981-1995) and teacher education (1976-1981 and 1995-present). He is now in the School of Education, at the Faculty of Health, Education and Society.

Steve teaches on a number of undergraduate and post-graduate teacher education programmes in the UK and overseas. He researches into e-learning and distance education, with particular emphasis on the pedagogy underlying the use of social media and Web 2.0 tools, and he also has research interests in mobile learning and cyber-cultures. Steve is regularly invited to speak about his work and has given keynotes and invited lectures to audiences in 30 countries across 5 continents. He is currently involved in several research programmes related to e-learning, social media and handheld technologies.

Steve is the author of more than 150 scholarly articles, with over 2500 academic citations and is an active and prolific edublogger. His blog Learning with ‘e’s is a regular online commentary on the social and cultural impact of disruptive technologies, and the application of digital media in education and training. It currently attracts in excess of 150,000 views each month.

Steve is chair of the Plymouth e-Learning Conference, and between 2008-2011 was also co-editor of the journal Interactive Learning Environments. He serves on the editorial boards of a number of learning technology and education related open access academic journals including Research in Learning Technology (formerly ALT-J), the International Review of Research in Open and Distance Learning (IRRODL), the European Journal of Open, Distance and eLearning (EURODL) and Digital Culture and Education. He has served on the organising and executive committees of a number of international academic conferences, including ALT-C, ICL, EDEN, IFIP and AICT.

In 2008 Steve was awarded a Fellowship by the European Distance and E-learning Network (EDEN), and in 2011 he was elected to serve as a member of the Steering group of EDEN’s Network of Academics and Professionals (NAP). Between 2008-2013 he also served as chair of the influential worldwide research group IFIP Technical Committee Working Group 3.6 (distance education) and is author of several books including The Digital Classroom (Routledge: 2008) and Connected Minds, Emerging Cultures (Information Age: 2009). He lives in Plymouth, on the South West coast of England.

Mathematics Teaching
Is the Future Syncretic?

Larissa Fradkin
London South Bank University, Brunel University and Sound Mathematics Ltd., U.K.

EXTENDEND ABSTRACT

Teaching is one of the oldest professions on Earth and mathematics teaching must have had come first, since it appears that numbers had been invented before letters! Yet "mathematics wars" have been raging throughout the XX century and technology has only added fuel to fire: should mathematics be taught as poetry, requiring an inordinate amount of memorising and practising or should teachers concentrate on abstract concepts, with the tedium of calculations left to calculators and computers? Can ordinary learners grasp abstract concepts at all? On top of that, a modern University maths teacher teaching STEM students, particularly, future engineers has to cope with large classes, much larger than most European teachers had to deal with in the past. Can any of the teaching approaches be implemented in such environment in an effective manner? The advent of the XXI century saw mathematics teachers cajoled into employing the "evidence-based" technological solutions that had been shown to work when training University administrators, business managers or technicians. Many resisted, arguing that maths learning is a different process to learning a few words and procedures. Now it is all about Massive Online Open Courses and Flipped Classrooms. Can ordinary engineering students learn mathematics by watching MIT or Khan Academy videos? Can ordinary mathematics teachers facilitate the process by "flipping" in an effective way? I will present my thoughts on the subject, argue against false dichotomies and suggest syncretic solutions, including the ones that rely on cognitive technologies of the future.

I will start discussing several myths that became popular among educationalists:

Only what students discover for themselves is truly learned, while in reality students learn in a variety of ways. Recent research has shown that basing most learning on student discovery is time-consuming, does not insure that students end up learning the right concepts, and can delay or prevent progression to the next level. Successful programs use discovery for only a few very carefully selected topics, never all topics.

There are two separate and distinct ways to teach mathematics,… conceptual understanding through a problem solving approach and through drill and kill, while according to many experts success in mathematics needs to be grounded in well-learned algorithms as well as understanding of the concepts.

*Math concepts are best understood and mastered when presented "in context"; in that way, the underlying math concept will follow automatically, even though it has been repeatedly shown that w*hen story problems take centre stage, the math it leads to is often not practiced or applied widely enough for students to learn how to apply the concept to other problems.

I will move to recent MOOCs data that show that the pass rates of current MOOCs registrants are low and the overwhelming majority of those who obtain the certificate of achievement already have a degree. I will suggest my answers to the question posed by these data "What are MOOCs missing?" I will suggest that they open a door to advanced cognitive tutors that employ the oldest and best teaching method – Socratic dialogue, which allow students to master abstract concepts and practice under "expert supervision" at the time and place of their choosing.

Finally, I will address the suggestion that because of MOOCs in 50 years there will be only 10 institutions in the world delivering higher education. However, I would argue – in line with many other academics – that, particularly in the first year of their academic studies, students, disadvantaged STEM students need intensive guided teaching. This

can be delivered only in person and only by the most experienced teachers capable of not just “talking” – delivering content, but mainly of “listening” – and readjusting their delivery depending on the student immediate feedback. Of course, these experienced teachers and their students would benefit from access to quality MOOCs.

BRIEF BIOGRAPHY

Larissa Fradkin is Emerita Professor, London South Bank University, UK and Associated Professor, Brunel University, UK. Trained as a physicist at St Petersburg University, Russia, from 1974 till 1977 she studied for her PhD in Applied Mathematics at Victoria University of Wellington, New Zealand. From 1978 till 1984 she was employed as a Research Scientist at the NZ Department of Scientific and Industrial Research and from 1985 till 1992, as a Research Associate at the Department of Applied Mathematics and Theoretical Physics of Cambridge University, UK. From 1993 till 2009 Larissa was a member of academic staff at London South Bank University where she created and ran a Research Group on Mathematical Modelling of Ultrasonic NDE (Non-Destructive Evaluation of industrial components and materials) and teaching mathematics on various engineering courses. She is now a Managing Director of an independent research organisation Sound Mathematics Ltd., working on her ultrasonic projects, mainly in collaboration with CEA (the French Atomic Commission) and promoting sound mathematics education of engineers. Larissa is a Fellow of IMA (UK Institute for Mathematics and Its Applications), IOP (UK Institute of Physics) and IET (UK Institute of Engineering and Technology). Larisa has authored and co-authored over a 100 scientific and scholarly publications, lately on pedagogy behind her system of maths teaching and in 2013 Bookboon has published her open access e-textbook “College Algebra and Calculus: The Whys and Hows.” Larissa has been a member of organising committees of several international engineering conferences and is currently a UK National contact person for SEFI’s Maths Working Group (SEFI is the European Society for Engineering Education) and a member of the Committee on Mathematical Education for Engineers, iNEER (International Network for Engineering Education and Research).
Larissa lives in Cambridge, England.

Team Learning in Engineering Education

Erik de Graaff
Aalborg University, Denmark

Abstract: Most engineers work in teams during their professional life. Hence, learning to be an effective team member is an essential aspect of preparing for engineering practice. This presentation will analyse how Problem Based Learning (PBL) supports students in engineering in developing teamwork skills, like leadership, communication skills, and the ability to correctly assess your own contribution to the teamwork. Several tools that support this process will be discussed.

BRIEF BIOGRAPHY

Erik de Graaff is trained as psychologist and holds a PhD in social sciences. He has been working with Problem Based learning (PBL) in Maastricht from 1979 till 1990. In 1994 he was appointed as associate professor in the field of educational innovation at the Faculty of Technology Policy and Management of Delft University of Technology. Dr. de Graaff has been a visiting professor at the University of Newcastle, Australia in 1995 and a guest professor at Aalborg University in Denmark. The collaboration with Aalborg University led to an appointment as full professor at the department of Development and Planning in 2011. Dr. de Graaff is recognized as an international expert on PBL. He contributed to the promotion of knowledge and understanding of higher engineering education with numerous publications and through active participation in professional organizations like SEFI, IGIP, IFEES and ALE. He has published over 200 articles and papers and he has presented more than 70 keynotes and invited lectures on various topics related to PBL in higher education, like: Working with PBL, Management of change, Assessment and evaluation, Methods of applied research and Collaboration between university and industry. Since January 2008 he is Editor-in-Chief of the European Journal of Engineering Education.

SOCIAL CONTEXT AND LEARNING ENVIRONMENTS

FULL PAPERS

Structuring Collaboration Scripts

Optimizing Online Group Work on Classroom Dilemmas in Teacher Education

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Keywords: Serious Games, Scripted Collaboration, Structure, Classroom Dilemmas, Teacher Education.

Abstract: The optimal structure in collaboration scripts for serious games has appeared to be a key success factor. In this study we compare a 'high- structured' and 'low-structured' version of a mastership game where teachers-in-training discuss solutions on classroom dilemmas. We collected data on the differences in learning effects and student appreciation. The most interesting result shows that reports delivered by students that played the low-structured version received significantly higher teacher grades when compared to the high-structured version. [A shortened version of the paper has been included for copyright reasons.]

1 BACKGROUND

Serious games not only support individual learning but also foster the acquisition of soft skills like collaboration and reflection about wicked problems, that are usually not addressed by other learning platforms (Gee, 2003). Workplace learning is shifting focus from individuals acquiring and updating domain knowledge towards selecting and using this knowledge for certain problem situations in daily practice where collaboration plays a crucial role.

Games are heavily inspired by experiential learning principles which hold potential for contextualised workplace learning. Serious games appear suitable as flexible learning environments where professional tasks can be carried out with little or no direct intervention of experts or teachers (e.g., Bell et al., 2008). How much erroneous or meaningful learning takes place will depend on the support that is provided, shared and distributed in the gaming environment. Collaboration support *within* a game has to be enabled by a didactic 'script' which we will name 'scripted collaboration'.

Collaboration scripts (Kobbe et al., 2007) are an instructional method that structures the collaboration by guiding the interacting partners online through a sequence of interaction phases with designated activities and roles. Such collaboration scripts have hardly ever been implemented and tested in more open learning environments like serious games (Dillenbourg and Hong, 2008). No research has focused on defining or optimizing the essential elements (e.g., of structure) or has measured the learning effects of including such scripting in serious game play.

Structure is defined here as the amount of restriction imposed on the freedom that is allowed in the group collaboration process. An optimal level of structure appears to be a key success factor for effective learner support. In a previous study we found that students complained about the complexity and task instruction within for the mastership game (Hummel et al., 2013). Building on Dillenbourg's (2002) risks of over-scripting we argue that *segmentation* and *inter-dependency* within the task constitute the main structure elements. An holistic task is less structured than a task that has been segmented in various consecutive subtasks; a task that can be carried out independently is less structured than a task that depends on synchronisation or approval of peers and / or teachers. We have further operationalized these structure elements and high/medium/low levels of structure for this study.

The Mastership game helps students to find solutions to the most prevailing practical classroom management dilemmas in a playful and collaborative way, a way that will help them become better teachers. The game was originally developed as a card game to be played face-to-face in small groups

(Geerts et al., 2009), and was later transformed into on online game to be played synchronously with freedom of place (Hummel et al., 2013).

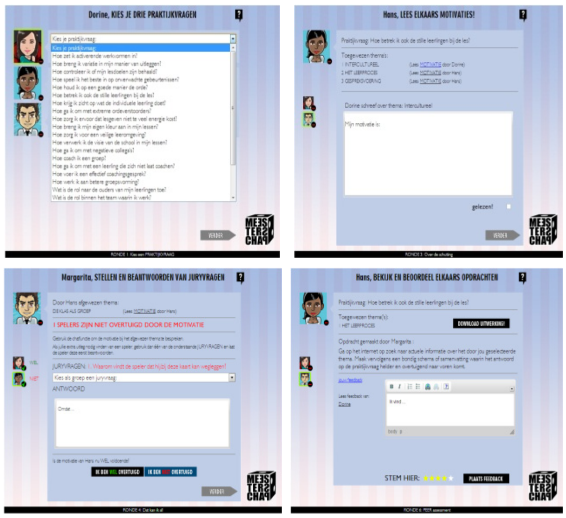

Figure 1: Screens of the online version of the Mastership game: selecting three practical dilemmas in phase 1 (upper left hand), assigning and motivating themes in phase 3 (upper right hand), motivating and discussing declined themes in phase 4 (lower left hand), and peer assessment of elaborated assignments in phase 6 (lower right hand).

The online Mastership game (for an impression see Figure 1) can be played in small groups of two till six students and does not require any intervention by teachers. After selecting their avatars, students start group play both in the role of player (or problem owner) and of co-player (judging the way that players solve their problems). The game has a structure that consists of five consecutive phases, during which players discuss, elaborate and negotiate solutions to solve each other's problems. Communication is structured by various assignments and rules during these phases, but is possible by unstructured group chat as well. During the *fifth phase* players select a practical assignment and use their co-players' input to further elaborate their solution in a short advisory report.

The main hypotheses (research questions) to be answered are twofold: (1) Will less structure lead to more 'natural' and effective collaborative learning?; and (2) Will less structure in the collaboration be appreciated more by students?

2 STUDY SET-UP

Third year students of the NHL University of Applied Science in the Netherlands participated in this case study as part of their regular curriculum. Participants are qualifying for a broad variety of first degree teaching positions, ranging from modern languages teaching, teaching didactics to science teaching. All students were approached by their teacher and invited to be present at a certain place and time at the university for a two-hour meeting. Participants were notified in advance that this meeting would also be used for study purposes, and were randomly allocated to one of three conditions (high-structured, low-structured, control).

Participants in the control group had to solve the practical classroom dilemma individually without playing the collaboration game. Each gaming condition contained two groups (of four or five students each). The players received an e-mail before the meeting, containing the URL and their personal account. All playing participants received a questionnaire about their appreciation of the game by e-mail a day after playing the game. At the time of the meeting, playing participants went to a computer room to work together online. A teacher was present in this computer room to control for direct (non)verbal communication beyond the program. During the time of the meeting, students in the control group individually worked on their practical task, without playing the game. For the purpose of this study we included a *sixth* and final *phase* in which students had to grade the reports of their peers, in order to enable a comparison of the assessments by peers (co-players) and teachers.

To measure individual learning output, the quality of the solutions provided for the classroom dilemmas was assessed by using a *learning effect correction model*, that was developed by the topic expert. The elaborated reports can be assessed on 'growth in professional productivity', and the five criteria to establish this growth were inspired by the development of 'design practice' (or practical theory) (Copeland and D'Emidio-Caston, 1998): A. Ownership (to what extent does student commit to solve this problem); B. Reflection (to what extent does student reflect on his own actions); C. Focus (to what extent does student attach the right amount of context to the problem); D. Nuance / Complexity (to what extent is applying the solution feasible); and E. Richness / Correctness (of the elaborated solution). Sufficient inter-rater reliability of the instrument was determined in a previous study (Hummel et al. , 2013).

The *student satisfaction questionnaire* was developed for this study by a learning technology expert. It contains 19 items to establish the students' appreciation of various game aspects, pertaining to the structure (5 questions), user-friendliness and clarity (5 questions), the timing of the phases (2 questions), the quality of the dilemmas and assignments (5 questions), and the interaction during collaboration (2 questions).

3 RESULTS

We found that most individual reports (76%) could be graded as sufficient. The average grade for all participants was $M = 6.62$, $SD = 1.29$. We added a control group to establish if playing the game does contribute *at all* to learning. As you see in Table 1 the average teacher grades for the control group were indeed lowest, so there appears to be an effect of playing the game. This effect appears significant when we compare the non-playing group to the low-structured (t (18) = 2.97, $p < 0.01$) and the medium-structured condition (which we left out of the analyses). However, we could not observe a significant difference between non-players and those playing the high-structured version (t (17) = 0.67, p = 0.51).

Table 1: Average report grades for all conditions, both from teachers and peers.

	High structure ($n = 9$)	Low structure ($n = 10$)	Control ($n = 10$)	All ($N = 29$)
Assessment	*M* *SD*	*M* *SD*	*M* *SD*	*M* *SD*
Teacher grade	6.44 1.59	7.35 1.03	6.05 0.93	6.62 1.29
Peer rating	7.93 .66	7.52 1.04	7.68 0.89	7.70 0.87

When looking for an overall effect of condition (N = 29) on learning effect we see a clear trend: low-structure scores best, than high-structure, and finally the control group. This effect is ‘marginally’ significant (F (2, 26) = 3.072, MSE = 4.428, p = 0.063, $\eta_p^2 = 0.18$), with values of the partial-eta-squared above .13 showing large effect size according to Cohen (1988). On top of this and even more importantly for the central research question, a significant difference (t (17) = 4,86, p = 0.042) is found in favour of low-structure when comparing with high-structure (N= 19). When looking at the peer ratings, we do not find any significant differences between conditions.

For most items in the student satisfaction questionnaire we did not find significant differences between both versions of the game, with just two exceptions. The low-structured group showed to be more satisfied with the amount of time to play (item 6). The high-structured group indicated that the overall structure was too high (item 11), a finding in line with what was reported on learning effects. It did not become clear that low-structure was appreciated more by students on various aspects.

We may conclude that collaboration can be successfully facilitated by scripting serious games when we take into account the importance of good instruction and optimal structure. This study found that over-scripting may indeed have disruptive learning effects. Players of the low-structured version of the mastership game produced reports that were graded significantly higher than the ones of those playing the high-structured version (and of those not playing the game).

For the generalizability of these findings it will be useful to carry out studies that research the effectiveness of other types of collaboration scripts and implementations in other domains.

ACKNOWLEDGEMENTS

This study was carried out as research activity within the ‘Learning Media’ program of CELSTEC (Open University of the Netherlands), and within the Lectorate ‘Workplace Learning and ICT’ (NHL University of Applied Science, The Netherlands). Authors and developers from both institutes worked closely together during development of the game and this study. We express our thanks to both institutes for their funding, and to NHL students for participating.

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MOOCs
A Review of the State-of-the-Art

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Keywords: Massive Open Online Courses, MOOCs, OER, Learning Theories, Assessment.

Abstract: Massive open online courses (MOOCs) have drastically changed the way we learn as well as how we teach. The main aim of MOOCs is to provide new opportunities to a massive number of learners to attend free online courses from anywhere all over the world. MOOCs have unique features that make it an effective technology-enhanced learning (TEL) model in higher education and beyond. The number of academic publications around MOOCs has grown rapidly in the last few years. The purpose of this paper is to compile and analyze the state-of-the-art in MOOC research that has been conducted in the past five years. A template analysis was used to map the conducted research on MOOCs into seven dimensions, namely concept, design, learning theories, case studies, business model, targets groups, and assessment. This classification schema aims at providing a comprehensive overview for readers who are interested in MOOCs to foster a common understanding of key concepts in this emerging field. The paper further suggests new challenges and opportunities for future work in the area of MOOCs that will support communication between researchers as they seek to address these challenges.

1 INTRODUCTION

Massive open online courses (MOOCs) have attracted a great deal of interest in educational institutions. MOOCs anticipate leading the new revolution of technology-enhanced learning (TEL), by providing new opportunities to a massive number of learners to attend free online courses from anywhere all over the world (Liyanagunawardena et al., 2013a). Over the last few years, the MOOCs phenomenon has become widely acknowledged as crucial for freely accessible high quality courses provided by international institutes for informal as well as formal education (Brown, 2013).

In recent years, topics around MOOCs are widely discussed across a range of academic publications from different theoretical and practical perspectives, including numerous implementations and design concepts of MOOCs. These publications are however still in an infancy stage and a systematic classification of the MOOC literature is still missing. This paper is one of the efforts to:

1. Compile and analyze the state-of-the-art that has been conducted on MOOCs between 2008 and 2013 to build a deep and better understanding of key concepts in this emerging field.
2. Identify some future research opportunities in the area of MOOCs that should be considered in the development of MOOCs environments.

In the light of these goals, this paper will discuss different angles of MOOCs and is structured as follows: Section 2 is a review of the related work. Section 3 describes the research methodology and how we collected the research data. In section 4, we review and discuss the state-of-the-art based on several dimensions. Finally, Section 5 gives a summary of the main findings of this paper and as a result highlights new opportunities for future work.

2 RELATED WORK

Since research in MOOCs is still an emerging field, we found only one systematic study of the published literature of MOOCs from 2008-2012, done by Liyanagunawardena et al. (2013b). The study provides a quantitative analysis of 45 peer reviewed studies and provides a general discussion based on a categorization into eight dimensions, namely introductory, concept, case studies, educational theory, technology, participant focused, provider focused, and other.

As compared to Liyanagunawardena et al.'s study, our study adds a wide range of peer-reviewed publications that have been conducted between 2008 and 2013 and provides a quantitative as well as qualitative analysis of the MOOC literature. Moreover, we apply a template analysis to categorize the MOOCs state-of-the-art into several dimensions. The study further provides critical discussion according to each dimension and suggests new opportunities for future research in MOOCs.

3 METHODOLOGY

The research was carried out in two main phases including data collection followed by template analysis of the literature review.

3.1 Data Collection

We collected data by applying the scientific research method of identifying papers from internet resources (Fink, 2005). This method includes three rounds. Firstly, we searched 7 major refereed academic databases[1] and secondly 18 academic journals[2] in the field of education technology and e-learning indexed by Journal Citation Reports (JCR), using the search terms (and their plurals) "MOOC", "Massive Open Online Course" and "Massively Open Online Course". These two rounds resulted in 128 peer-reviewed papers to be included in our study.

Thirdly, we applied a set of selection criteria as follows:

1. Research must focus on MOOCs in pedagogical, social, economic, and technical settings. Studies with political and policymakers views were excluded.
2. Papers providing experimental or empirical studies from actual observations and case studies with scientific data were included.
3. Papers presenting a new design of MOOCs were included. Studies with personal opinions or learner's anecdotal impression were excluded.

The result was 84 peer-reviewed publications which fit the criteria above (80 papers, 3 international reports, and 1 dissertation). Figure 1 shows the number of MOOCs publications between 2008 and 2013 which were found to be relevant for this study.

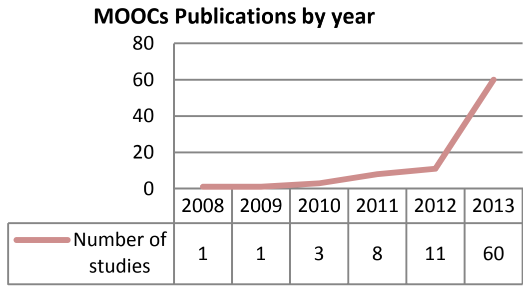

Figure 1: MOOCs papers by publication year.

3.2 Template Analysis

The second phase was using Template Analysis as classification technique for mapping MOOCs literature in several dimensions (King, 2004). In the first level of template analysis, we carefully read the MOOCs literature to be familiar with the domain context. Then, in the second level we formulated concrete codes (themes), based on the understanding of the studies domain and using the existing classifications by Liyanagunawardena et al. (2013b) and Pardos and Schneider (2013) as a reference to test reliability and credibility. Then, we identified seven codes as follows:

1. **Concept** included aspects in the literature which referred to the concept e.g. definition, history, and MOOCs types.
2. **Design** included design principals e.g. pedagogical and technological features.
3. **Learning theories** that have built the theoretical

[1] Education Resources Information Center (ERIC), JSTOR, ALT Open Access Repository, Google Scholar, PsychInfo, ACM publication, IEEEXplorer, and Wiley Online Library

[2] American Journal of Distance Education, Australian Journal of Educational Technology, British Journal of Educational Technology, Canadian Journal of Learning and Technology, Communications of the ACM, Continuing Higher Education Review Journal, Educational Technology Research and Development, Educational Theory, eLearning Papers Journal, Frontiers of Language and Teaching, International Journal of Innovation in Education, International Journal of Technology in Teaching and Learning, International Review of Research in Open and Distance Learning, Journal of Asynchronous Learning Networks, Journal of Computer Assisted Learning, Journal of Interactive Media in Education (JIME), Open Praxis Journal, The European Journal of Open, and Distance and E-Learning (EURODL)

background of the conducted MOOC studies.
4. **Case studies** e.g. experimental and empirical studies.
5. **Business models** that have been followed in the different MOOC implementations.
6. **Target groups** included aspects which referred to learner characteristics.
7. **Assessment** included different types in MOOCs e.g. e-assessment, self-assessments, and peer-assessment.

After having a stable code template, we had several internal meetings to discuss each code and create a mapping of the 84 publications that were selected in this review into the seven identified codes as depicted in Figure 2. This template analysis has been done manually using printout tables.

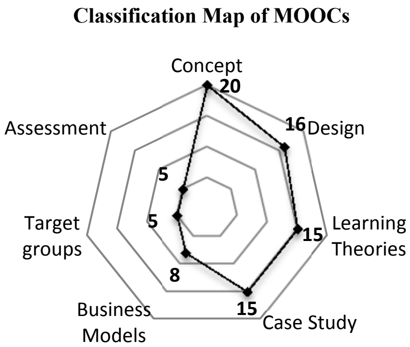

Figure 2: Classification Map of MOOCs.

4 MOOC STATE-OF-THE-ART

In this section, we analyze and discuss in detail the MOOCs state-of-the-art based on the template analysis dimensions (codes) that have been identified in Section 3. For the critical discussion part, we apply the meta-analysis method which aims to contrast and combine results from several studies into a single scientific work (Fink, 2005).

4.1 Concept

The first dimension in our analysis is "concept". Nearly 25% of the literature reviewed in this paper focus on the MOOC concept. To clarify the MOOC concept three aspects have been considered in the reviewed literature, namely definition, history, and types.

4.1.1 MOOC Definition

Various definitions have been provided for the term MOOC by describing the four words in the MOOC acronym. The key elements of MOOCs are depicted in Figure 3:

- **Massive(ly):** In MOOCs, massiveness reflects the number of course participants. While most of the MOOCs had few hundred participants some courses reached over 150,000 registrations (Allen and Seaman, 2013); (Russell et al. 2013). Massive refers to the capacity of the course to expand to large numbers of learners (Anderson and McGreal, 2012). The challenge is to find the right balance between large number of participants, content quality, and individual needs of learners (Brown, 2013); (Esposito, 2012); (Laws et al., 2003).
- **Open:** Openness includes four dimensions (4Rs) Reuse, Revise, Remix, and Redistribute (Peter and Deimann, 2013). In the context of MOOCs, it refers to providing a learning experience to a vast number of participants around the globe regardless of their location, age, income, ideology, and level of education, without any entry requirements, or course fees to access high quality education. Openness can also refer to providing open educational resources (OER) e.g. course notes, PowerPoint presentations, video lectures, and assessment. (Anderson and McGreal, 2012); (Schuwer et al., 2013).
- **Online:** the term online refers to the accessibility of these courses form each spot of the world via internet connection to provide synchronous as well as asynchronous interaction between the course participants, (Brown, 2013); (Schuwer et al., 2013). In some variations of MOOCs (e.g. blended MOOCs), learners can learn at least in part face-to-face beside the online interaction possibilities (Stewart, 2013).
- **Courses:** The term course is defined in higher education as a unit of teaching. In MOOCs it refers to the academic curriculum to be delivered to the learners, including OER, learning objectives, networking tools, assessments, and learning analytics tools (Allen and Seaman, 2013); (Voss, 2013).

The original concept of MOOCs is to offer free and open access courses for massive number of learners. However, scalability issues and low completion rates, (less than 10% in most of the offered MOOCs) constantly concern the MOOC providers (Brown, 2013); (Trumbić and Daniel, 2013). Moreover,

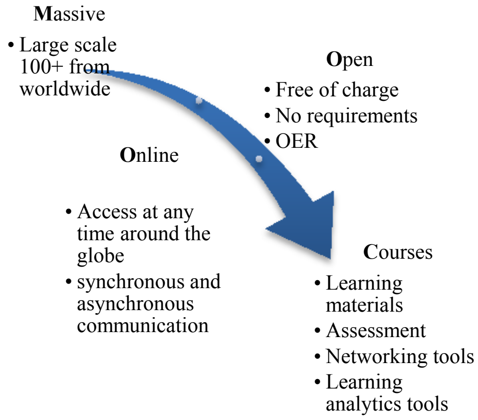

Figure 3: Key elements of MOOCs.

several MOOC providers either charge fees for their courses or offer courses for free but learners have to pay for exams, certificates, or teaching assistance from third party partners (Brown, 2013). Thus, we believe that the original definition of MOOCs will change as a result of the various challenges and rapid developments in this field.

4.1.2 MOOC History

Dave Cormier and Bryan Alexander coined the acronym MOOC to describe the "Connectivism and Connective Knowledge" (CCK08) course launched by Stephen Downes and George Siemens at the University of Manitoba in 2008 (Boven, 2013). This new form of learning and teaching has led Stanford University to offer three online courses in 2011 (Yuan and Powell, 2013a); (Rhoads, et al., 2013). These courses significantly succeeded in attracting a big number of participants, thus turning a qualitative leap in the field of MOOCs. Driven by the success of the Stanford MOOCs Sebastian Thrun and Peter Norvig started to think about MOOC business models and launched Udacity as a profit MOOC model in 2012 (Peter and Deimann, 2013). Two other Stanford professors Daphne Koller and

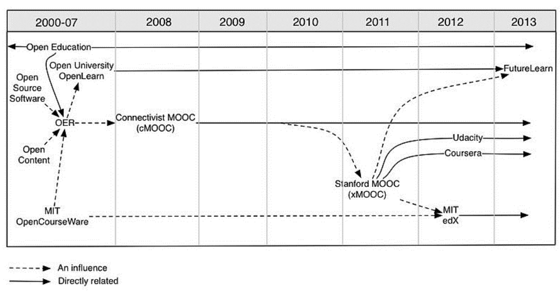

Figure 4: MOOCs and open education timeline (Yuan and Powell, 2013a).

Andrew Ng have also started their own company Coursera which partnered with dozens of renowned universities to provide a platform for online courses aiming at offering high quality education to interested learners all over the world. (Schuwer, and Janssen, 2013); (Dikeogu and Clark, 2013). Additionally, Massachusetts Institute of Technology (MIT) and Harvard University launched edX as a non-profit MOOC platform. Figure 4 shows the MOOC and open education timeline (Yuan and Powell, 2013a).
Although these MOOCs platforms have different objectives, they share the focus on building large learning networks beyond the traditional teaching environments.

4.1.3 MOOC Types

The current MOOC literature categorized MOOCs into two main types "cMOOCs" and "xMOOCs" (Smith and Eng, 2013). Moreover, new forms have emerged from xMOOCs. These include "smOOCs" and "bMOOCs". Figure 5 shows the different types of MOOCs and their underlying learning theories.

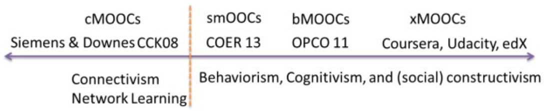

Figure 5: MOOC types.

The early MOOCs launched by Downes and Siemens (CCK08) were driven by the connectivism theory and were thus referred to as connectivist MOOCs (cMOOCs). cMOOCs provide space for self-organized learning where learners can define their own objectives, present their own view, and collaboratively create and share knowledge. cMOOCs enable learners to build their own networks via blogs, wikis, Google groups, Twitter, Facebook, and other social networking tools outside the learning platform without any restrictions from the teacher (Kruiderink, 2013). Moreover, peer-assessment was used to grade assignments or tests based on pre-defined rubrics that improve students' understanding of the content. Thus, cMOOCs are distributed and networked learning environments where learners are at the center of the learning process. Figure 6 depicts the key concepts of cMOOCs.

On the other hand, extension MOOCs (xMOOCs) e.g. Coursera, edX, and Udacity follow the behaviorism, cognitivist, and (social) constructivism learning theories. In fact, in xMOOCs, learning objectives are pre-defined by

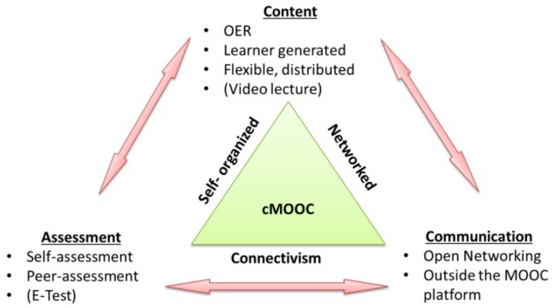

Figure 6: cMOOCs.

teachers who impart their knowledge through short video lectures, often followed by simple e-assessment tasks (e.g. quiz, eTest) (Kruiderink, 2013); (Stewart, 2013); (Daniel, 2012). Only few xMOOCs have used peer-assessment. Moreover, xMOOCs provide limited communication space between the course participants (Gaebel, 2013). Unlike cMOOCs, the communication in xMOOCs happens within the platform itself. The key concepts of xMOOCs are shown in Figure 7.

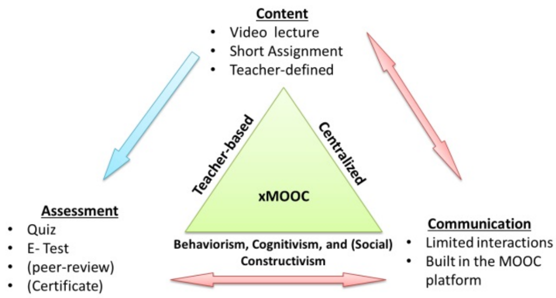

Figure 7: xMOOCs.

Recently, new forms of MOOCs have emerged. These include smOOCs as small open online courses with a relatively small number of participants (e.g. COER13) and blended MOOCs (bMOOCs) as hybrid MOOCs including in-class and online mediated instruction (e.g. OPCO11) with flexibility ways that learners can interacting in real-time that fit into around their motivation and to build learner commitment to the courses (Coates, 2013); (Gaebel, 2013); (Daniel, 2012).

4.2 Design

The reviewed studies on MOOCs design distinguish between pedagogical design principles that can engage learners to attend the courses and technological design principles that can make the MOOCs more dynamic.

4.2.1 Pedagogical Design Principles

Most of the teachers and researchers believe that MOOCs cannot completely replace traditional learning (Ovaska, 2013). As a consequence, there is an increasing focus on hybrid MOOCs (Szafir and Mutlu, 2013). In order to encourage learners to complete the course, Vihavainen, et al. (2012) offered bMOOCs with support of scaffolding of learner's tasks using a purpose-built assessment solution and continuous reflection between the learner and the advisor. In other studies, the integration of social networks in bMOOCs added new value in learner's interactions and activities (Morris, 2013); (Calter, 2013).

McCallum, Thomas and Libarkin, (2013) designed alphaMOOCs (aMOOCs) as a mix of cMOOCs and xMOOCs by building collaboration teams. McAndrew (2013) designed a project-based MOOC (pMOOC) by structuring the offered MOOC around a course-related project. Guàrdia, et al. (2013) analyzed the learners needs in a MOOC and presented a set of pedagogical design principles that focus on improving the interactions among learners. Bruff, et al (2013) discussed some pedagogical design ideas that provide guidance on how to design bMOOCs. The authors focused on competency-based design, self-paced learning, pre-definition of learning plans (objectives, schedules, and assignments), as well as open network interaction and collaboration tools that rise motivation and avoid losing interest and drop out from the course. And, Grünewald, et al. (2013) suggested peer-assistance through the course to solve learning difficulties.

4.2.2 Technological Design Principles

MOOCs are include several technology features that support different important activities in the learning experience such as interaction, collaboration, evaluation, and self-reflection (de Waard et al., 2011b); (Fournier et al., 2011). The tools used in the reviewed literature can be classified into three main categories, namely collaboration, assessment, and analytics tools.

Most of the MOOCs provide collaboration work spaces that include several tools to support learners in communicating with each other such as forums, blogs, video podcasts, social networks, and dashboards (McAndrew, 2013); (Mak et al., 2010). Different e-assessment methods are applied in MOOCs. While most of xMOOCs use traditional forms of e-assessment like eTests and Quizzes, cMOOCs rather focus on self-assessment and peer-assessment (Kellogg, 2013); (Spector, 2013).

In MOOCs it is difficult to provide personal feedback to a massive number of learners. Thus, several MOOC studies tried to apply learning analytics tools to monitor the learning process, identify difficulties, discover learning patterns, provide feedback, and support learners in reflecting on their own learning experience (Fournier et al., 2011); (Giannakos et al. 2013).

4.3 Learning Theories

How learners learn through MOOCs? In other words, how they absorb, process, build, and construct knowledge? This is a simple question, but the answer is quite complicated. Behaviorists and cognitivists believe that learning experience is a result of the human action with the learning environment (Kop and Hill, 2008). Constructivists, by contrast, believe that learning is an active process of creating meaning from different experiences and that learners learn better by doing (Anderson and Dron, 2011). In the last years, technology has changed the way we learn as well as we teach (Viswanathan, 2013). And, the social Web has provided new ways how we network and learn outside the classroom. These opportunities are reflected in recent learning theories and models. These include connectivism which views learning as a network-forming process (Martin, 2013); (Tschofen and Mackness, 2012); (Kop, 2011); (Siemens, 2005) and the Learning as a Network (LaaN) theory which starts from the learner and views learning as a continuous creation of a personal knowledge network (PKN) (Chatti, 2010).

Back to the main question how learners learn through MOOCs? As discussed in Section 4, MOOCs are running in two major categories: cMOOCs and xMOOCs. CCK08 was the first MOOC designed based on the principals of connectivism (Kop et al., 2011). The aim of CCK08 – and other cMOOCs – is to build and construct knowledge through the interaction in learner networks (Cabiria, 2012); (Bell, 2011); (Chamberlin and Parish, 2011). Rodriguez (2013) pointed out that some cMOOCs indeed succeeded to improve the learner's motivation. On the other hand, xMOOCs were based on the behaviorism and cognitivism theories with some (social) constructivism components that focus on learning by doing (i.e. experimental, project-based, or task-based) activities. This wave of MOOCs is similar to the traditional instructor-led courses offered at universities that are organized around video lectures, and e-assessment. Most of the researchers in the reviewed literature put a heavier focus on xMOOCs as a new model of learning and teaching in higher education (Milligan et al., 2013); (Rodriguez, 2012). Few researchers stressed the importance of social components in xMOOCs. Blom et al. (2013) reported that xMOOCs become more social using collaboration tools e.g. forums and wikis. Purser et al., (2012) suggested that the idea of peer-to-peer in collaborative learning helps learners to improve their learning outcome in xMOOCs.

In general, cMOOCs reflect the new learning environments characterized by flexibility and openness. On the other hand, xMOOCs offer high quality content as compared to cMOOCs. To fill this gap, hybrid MOOCs bMOOCs have been proposed to combine the advantages of both cMOOCs and xMOOCs.

4.4 Case Studies

Several case studies of MOOCs have been discussed in the reviewed literature. In Table 1, we compare different case studies in terms of learning theories, design elements, structure, tools, and assessment (Malan, 2013). We selected six case studies that are representatives for different MOOC types. To represent cMOOCs we selected CCK08 (Rodriguez, 2013); (Bell, 2010); (Mackness et al., 2010); (Fini, 2009). From xMOOCs we selected edX as non-profit platform and Coursera as profit platform (Cooper and Sahami, 2013); (Portmess, 2013); (Rodriguez, 2013); (Subbian, 2013); (Machun et al., 2012); (Hoyos et al., 2013). In addition, we selected OPCO11 as an example of bMOOCs and COER13 and MobiMOOC as examples of smOOCs (Arnold, 2012); (de Waard et al., 2011a); (Romero, 2013); (Koutropoulos, et al., 2012).

These different MOOCs share some common features that focus on video-based lectures, the support of open registration and informal learning, and the use of social tools. Most of the MOOCs apply traditional e-assessment tools (e.g. E-Tests, Quizzes, MCQ). Peer-assessment is mainly used in cMOOCs and bMOOCs and self-assessment rather in smOOCs. The majority of the reviewed case studies implement the behaviorism, cognitivism, and constructivism learning theories. Only few case studies (e.g. CCK08 and MobiMOOC) include elements that are borrowed from connectivism, such as personal learning environments and open networking.

Table 1: Comparison of MOOCs case studies.

Compare Item		CCK08	edX	Coursera	OPCO11	COER13	MobiMOOC
Learning theory	Connectivism	√	-	-	-	-	(√)
	Behaviorism	-	√	√	-	-	-
	Cognitivist	-	√	√	-	-	(√)
	Social constructivism	-	-	-	√	√	-
Assessment	E-Assessment	(√)	√	√	√	√	√
	Peer-Assessment	√	-	(√)	(√)	-	-
	Self-Assessment	-	-	-	-	(√)	(√)
Openness	Profit	-	-	√	-	-	-
	Open registration	√	√	√	√	√	√
	Download Material	-	√	(√)	(√)	(√)	√
Form	Formal Learning	(√)	-	(√)	(√)	-	-
	Informal Learning	√	√	√	√	√	√
Learning Tools	Video Lecture	√	√	√	√	√	√
	Face-to-Face	-	-	-	√	-	-
	Blogs, forums, social network	√	√	√	√	√	√
	Lecture Note, PPT and PDF	√	√	√	√	√	√

√ Completely (√) Partly - Not supported

4.5 Business Models

The initial vision of MOOCs was to provide open online courses that could reduce the cost of university-level education and reach thousands of low-income learners (Teplechuk, 2013); (Cusumano, 2013). Nevertheless, new business models have been launched e.g. in Coursera, Udacity, and Udemy. These business models are heralding a change in the education landscape that poses a threat to the quality of learning outcome and future educational pathways (Schuwer and Janssen, 2013); (Yuan, and Powell, 2013b).

Due to the huge budget that has been spent to develop MOOC platforms, MOOC providers are fighting to come up with new business models to satisfy their investors (Freeman and Hancock, 2013); (Guthrie et al, 2013).

Ruth (2012) reported his overview of potential business models such as offering courses for free and learners pay for certification, examination, and teaching assistance. Coursera, for instance, offers additional examinations for certificates. The question here is whether these certificates will be accepted. Green (2013) believes that if the universities provide MOOC credits, this will be a potential route to accept these certificates in the real market. To achieve this, MOOCs should meet the market needs by providing high quality content as well as high quality outcome (Lambert and Carter, 2013); (Gallagher and LaBrie, 2012).

4.6 Target Groups

Some demographics studies have been conducted to analyze target groups in MOOCs by determining their locations, age group, and learner patterns.

One major goal of MOOCs was to reach low-income learners particularly in developing countries. Studies, however, have shown that the vast majority of MOOC participants were from North America and Europe. Only few participate from South East Asia and fewer from Asia and Africa (Clow, 2013); (Liyanagunawardena et al., 2013a); (Stine, 2013). This is consistent with the analysis of 2.9 million participants registered in Coursera from 220 countries around the globe (Waldrop, 2013).

Possible obstacles that could prevent learners from Africa and Asia to take part in MOOCs include the poor technology infrastructure. Only 25% of Africa has electricity access (WEO-2012). And Africa has the lowest internet access all over the world with only 7% (Sanou, 2013). Asia is a continent with many different cultures and languages. Thus, linguistic issues could be a barrier to participate in MOOCs.

Stine (2013) and de Waard et al. (2011b) noted that around 50% of the participants from 31-50 age groups, which indicates that informal learners have more interest in MOOCs.

Several studies have reported a high drop-out rate that reflects the learner patterns in MOOCs (Waite, et al., 2013). Hill (2013) identified five patterns of participants in Coursera, as shown in Figure 8.

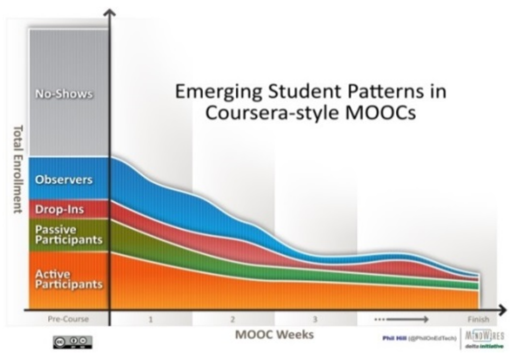

Figure 8: Pattern of participants in Coursera (Hill, 2013).

The vast majority were No-Shows participants who register but never log into the course. Secondly, observers who read content or discussions without submitting any assignments. Thirdly, Drop-ins participants who are doing some activities but do not complete the course. Fourthly, Passive participants who take the course and do tests but do not participate in the discussion. Fifthly, Active participants who regularly do all assignments and actively take part in the discussions.

Some studies explored pedagogical approaches to engage Observers, Drop-ins, and Passive participants to be active learners through e.g. game-based learning (Romero, 2013), social networking that help learners to create their own personal learning environments (Guàrdia, et al., 2013), and project-based learning (Irvine et al, 2013); (McAndrew, 2013).

4.7 Assessment

The ability to evaluate vast number of learners in MOOCs is indeed a big challenge (Yin and Kawachi, 2013). Thus, assessment is an important factor for the future success of MOOC. So far MOOC providers didn't offer official academic accreditation from their home institutions, which might indicate that the quality of learning outcome in MOOCs is different from university courses (Sandeen, 2013); (Gallagher and LaBrie, 2012). Currently, MOOCs are only providing a non-credit certificate e.g. completion, attendance, or participation certificate. In the reviewed literature, three main types of assessment were conducted in MOOCs, namely e-assessment, peer-assessment, and self-assessment.

4.7.1 e-Assessment

e-Assessment is often used in xMOOCs to gauge student performance. E-assessment in xMOOCs is restricted to closed question formats. These include exams with multiple choice questions based on machine grading (Conrad, 2013). This implementation of assessment is applicable in Science courses. It is, however difficult to apply e-assessment in Humanities courses due the nature of these courses which are based on the creativity and imagination of the learners (Sandeen, 2013).

4.7.2 Peer-assessment

Peer-assessment was used in cMOOCs and xMOOCs to review essays, projects, and team assignments. These assignments are not graded automatically, but learners themselves can evaluate and provide feedback on each other's work. This method of assessment is suitable in Humanities, Social Sciences and Business studies, which do not have clear right or wrong answers (O'Toole, 2013). Cooper and Sahami (2013) point out that, some learners in peer-assessment grade without reading the work to be reviewed or do not follow a clear grading scheme, which negatively impacts the quality of the given feedback. Therefore, more criteria and indicators are needed to ensure that peer-assessment is effective.

4.7.3 Self-assessment

Self-assessment is still not widely used in MOOCs. Sandeen (2013) and Piech et al. (2013) identified some self-assessment techniques. These include model answer as tool to students to cross check if the marks they scored are in tune with the model answers set by the educators, and learning analytics where the learners can self-reflect on their achievements.

5 CONCLUSION AND FUTURE WORK

MOOCs present an emerging branch of online learning that is gaining interest in the technology-enhanced learning (TEL) community. In the last few years after the launch of the first MOOC in 2008, a considerable number of research studies have been conducted to explore the potential of MOOCs to improve the effectiveness of the learning experience. The main aim of this paper was to compile and analyze the state-of-the-art in MOOC research that has been conducted in the past five years. 84 peer reviewed papers were selected in this study. A template analysis was applied to analyze and categorize the MOOCs literature into 7 dimensions, namely concept, design, learning theories, case studies, business models, target groups, and assessment.

The main result of our study is that the initial vision of MOOCs as a new learning environment that aims at breaking down obstacles to learning for anyone, anywhere and at any time around the globe is far away from the reality. In fact, most MOOC implementations so far still follow a top-down, controlled, teacher-centered, and centralized learning model. Attempts to implement bottom-up, student-centered, really open, and distributed forms of MOOCs are rather the exception rather than the rule. In general, MOOCs further require key stakeholders to address a number of challenges, including questions about hybrid education, role of the university/teacher, plagiarism, certification, completion rates, and innovation beyond traditional learning models. These challenges will need to be addressed as the understanding of the technical and pedagogical issues surrounding MOOCs evolves. In the following, we suggest research opportunities in relation to each dimension:

- *Concept:* More theoretical work is needed to achieve a common understanding of the MOOC concept as well as a systematic mapping between the course goals and the MOOC type to be implemented.
- *Design:* it is necessary to conduct research on how to improve the MOOC environments by investigating new learning models (e.g. personalized learning, project-based learning, game-based learning, inquiry-based learning) and tools (e.g. learning analytics).
- *Learning Theories:* It is crucial that future MOOC implementations are backed by a solid theoretical background. A heavier focus should be put on cMOOCs as well as bMOOCs which have the potential to support different learning models beyond formal institutional learning. These include informal learning, personalized learning, professional learning, and lifelong learning.
- *Case Studies*: The field of MOOCs is emerging and it is needed to conduct and share more experimental studies with different MOOC formats and variations.
- *Business Models*: We need to identify new ways to think about business models that preserve the quality of the learning experience supported by MOOCs.
- *Target Groups:* We need to investigate new methods to increase the motivation of observers, drop-ins and passive learners in MOOCs through e.g. learning analytics.
- *Assessment:* it is necessary to go beyond traditional e-assessment methods and apply open assessment methods that fit better to the MOOC environments characterized by openness, networking, and self-organization.

This paper which compiles and analyzes the state-of-the-art in MOOC research is original because firstly it provides a comprehensive review of the development of MOOCs which have been lacking until now and secondly it examines the context within which further work can take place by identifying key challenges and opportunities that lie ahead in this emerging research area.

Our future work will focus on learner-centered MOOCs by providing a MOOC platform where learners can take an active role in the management of their learning environments, through self-organized dashboards and collaborative workspaces. The platform will be based on an app system that enables learners to select the apps according to their needs and preferences. These include a collaborative video annotation app as well as learning analytics apps to support self-reflection, awareness, and self-assessment.

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Introducing Accessibility for Blind Users to Sighted Computer Science Students

The Aesthetics of Tools, Pursuits, and Characters

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Abstract: We analyze current approaches in motivating students to pursue accessibility, with a focus on blind users, by examining scientific reports of courses in the computer science and engineering curriculum. We identify three main motivational resorts: a 'web of arguments', referring to issues of morality, legality, and interest; the practice of mainstreaming, which normalizes accessibility, and empathy. We argue that an aesthetic frame could contribute to a forceful, persistent motivation, and we propose an aesthetic motivational repertoire, on three dimensions: aesthetic value of technological tools, of engineers' own work, and of their direct and indirect relationships with blind persons. We present arguments, practices, and online resources to support teachers that introduce accessibility for blind users to sighted students.

1 INTRODUCTION

There is a significant thread of research dedicated to teaching accessibility for computer science and engineering students. We are interested in examining how authors (who, in these cases, are also teachers) justify the importance of teaching accessibility, and how they address students' interests and concerns. We argue that the dominant approach can be enriched in order to support persistent motivation for accessible design – that is, outside of the University campus, after graduation, when IT professionals have to confront competing demands and conflicting priorities. We propose that *aesthetic experiences* – as regards technological tools, one's own engineering work, and blind user characters – can consolidate the current modus operandi for motivating students, which is mostly focused on considerations of legality, altruism, and profit.

The paper is structured as follows: we first analyze the literature concerning accessibility in the computer science curriculum, and we highlight the dominant motivational approach, identifying three resorts: the '*web of arguments*', *mainstreaming*, and *empathy*. We then go on to propose *aesthetic* considerations as an additional resource, in relation to three issues: the aesthetics of the *technologies* designed by computer specialists, of their *work*, and of the blind *characters* with which they establish a relationship through their performance. Students' construction of *blind personas* can be a useful and flexible learning tool with an aesthetic edge. The final section concludes the paper.

2 INDUCING ACCESSIBLE DESIGN: THREE PILLARS

Teachers of accessible design appeal to three ways of engaging their students with this perspective: *argumentation*, persuasion through *empathy*, and routinization through *mainstreaming*.

2.1 The Web of Arguments

In articles that discuss various approaches to teaching accessibility, the value of introducing it to students is not treated as a self-evident matter: most authors offer a justification, relying on several arguments (Ludi, 2002; Rosmaita, 2006; Cohen, Fairley, Gerry, & Lima, 2005; Harrison, 2005).

The "*social responsibility argument*" (Rosmaita, 2006), or *ethical reasoning* (Wang, 2012), appeals to the goal of universal access for the World Wide

Web, as stated by the World Wide Web Consortium (W3C). The "Web for All" design principle stipulates: "The social value of the Web is that it enables human communication, commerce, and opportunities to share knowledge. One of W3C's primary goals is to make these benefits available to all people, whatever their hardware, software, network infrastructure, native language, culture, geographical location, or physical or mental ability" (W3C, 2012a). W3C pursues this goal via the Web Accessibility Initiative (WAI), that develops the Web Content Accessibility Guidelines (WCAG) (W3C, 2012b).

The "*legal argument*" (Rosmaita, 2006; Wang, 2012) invokes legal requirements for Internet accessibility; for example, in the United States these derive from the Section 508 of the Rehabilitation Act. Rising numbers of impaired students bring to the forefront the issue of legally mandated equal access in education (Cohen et al., 2005). In countries where such legal requirements exist, skills for accessibility design contribute to *employability* and can thus be shown to be useful for students' future careers (Ludi, 2002; Cohen et al., 2005).

The *market* argument stresses the fact that impaired users represent a significant proportion of citizens and customers, which are lost through inaccessible design (Ludi, 2002); this argument also capitalizes on utility, this time from a business perspective, complementing the increased employability.

The "*march of technology*" argument (Rosmaita, 2006) points to the fact that accessibility does not refer to impaired users only, but also to *all users in restricted contexts* that become increasingly common as technology permeates more areas of life: "Automobile drivers—who otherwise have normal vision—are blind with respect to the web while they are driving. Likewise, a person surfing the web on a small mobile handheld device is, for all intents and purposes, a low-vision person accessing the web" (ibid., p. 271).

The argument of *direct benefits for all users* adds that we-as-able-users are likely to become closely involved with impaired users, as we, our parents, and significant others age (Ludi, 2002): "Visually impaired computer users are a minority, but it's a growing minority, and it is growing faster as baby boomers near retirement age. Further, it's a minority that will eventually include us all" (Rosmaita, 2006, p. 274). This argument lends further support to the market-related considerations.

The "*technical reason*" (Wang, 2012) indicates that designing for accessibility increases interoperability and standard compliance (also pointed out by Rosmaita, 2006), thus serving the general public and increasing designers' skills and employability (Waller, Hanson, & Sloan, 2009).

Overall, these arguments capitalize on accessibility as a matter of a) *morality* – addressing disabled people's needs and rights, b) abiding the law – and c) a matter of *interest* – for developer employees, for businesses, and for the government. In a nutshell, "the audience is growing, the law requires it, and the industry trend is toward it" (Harrison, 2005, p. 23).

Authors also address potential counter-arguments. The issue of *cost* appears as the most prominent expected hurdle: "I think that all would agree that when faced with an inaccessible website and an accessible website with the same functionality, the accessible website is better. The debate is really over who pays to implement accessibility, and why they should have to bear that cost" (Rosmaita, 2006, p. 274). How do authors address the issue of cost? There are two main answers. On the one hand, accessibility is deemed "lightweight to introduce" (Cohen et al., 2005) – that is, costs are not high, when introduced skillfully and early. On the other hand, retrofitting accessibility is significantly more costly, therefore it is better to design directly for accessibility (Cohen et al., 2005; Rosmaita, 2006).

Another expected counter-argument, introduced by Waller et al. (2009), is that designing for accessibility might "stifle" creativity (rather than "spark" it), and it might lead into tradeoffs with other important considerations such as "design goals, technological limitations, customer objectives and software objectives" (p. 157). There are no explicit answers advanced for this concern.

Both types of counter-arguments raise the following question: how can students approach accessibility so that they would continue to engage it outside of the classroom, when facing such counter-arguments from team members or leaders (or even from within themselves)? Each project has to navigate a plethora of competing requirements and considerations: how can accessibility stand a chance against issues of beautiful design, or the use of innovative-but-inaccessible technologies to entice large numbers of mostly-able users? Since, for any argument, there is a counter-argument, providing students a set of good justifications for accessible design seems to be necessary, but not sufficient for successful confrontations 'in the field'.

2.2 Empathy

A second resource for strengthening motivation for accessibility consists in cultivating sighted students' *empathy* with blind people, through a closer experience of their living situations and perspectives. There are several means through which teachers of accessibility cultivate empathy, as discussed in the reviewed publications.

The first such means is *literature*: Rosmaita (2006) requires students to read Rod Michalko's memoir *The Two-in-One* (R. Michalko, 1998); Michalko is a sociology professor who has written compelling accounts of blindness and analyses of the "sighted world" (R. L. Michalko, 1977), including the University classroom (R. Michalko, 2001), by examining interactions between blind and sighted people.

The second avenue for introducing students to the experiences of blind people consists in face-to-face communication – that is, *actually meeting blind people*. Such encounters can be organized as lectures from blind academics, discussions with blind users of technology (Harrison, 2005), possibly also blind students (Rosmaita, 2006), or, at a higher level of complexity, collaboration with blind people in design projects (Waller et al., 2009).

The third way of cultivating empathy is to ask able students to *simulate blindness* while using computers, for example, by turning off the monitor and navigating with a screen reader (Freire, de Mattos Fortes, Barroso Paiva, & Santos Turine, 2007; Harrison, 2005; Rosmaita, 2006).

2.3 Mainstreaming

A third resource deemed useful for long term motivation refers to how accessibility is framed through curriculum design. The aim is to cultivate an appreciation of accessibility as a default option, a norm rather than an exception or an add-on feature. A resource for framing accessibility as normality, rather than a feature marked as controversial and optional, consists in *mainstreaming* it throughout the curriculum (Waller et al., 2009), by including it in multiple areas and types of learning activities, or throughout a given course (Ludi, 2002; Wang, 2012; Harrison, 2005), by including it in multiple lectures and assignments rather than as a specific, isolated discussion.

Mainstreaming accessibility has two advantages: at a *symbolic* level, it un-marks it as a special topic, rendering it a normal and strongly normative requirement. As regards *skills*, students face challenges of accessible design continuously, in multiple tasks and projects. If it becomes routine, accessible design escapes the need for justification: it is just how it's done. Mainstreaming accessibility throughout a course or program curriculum is expected to achieve a *routinization of concern*, thus going 'under the radar' of competing arguments.

3 AESTHETICS: A NEW PILLAR

We propose that there is a fourth pillar for sustaining long-term student motivation, besides the web of arguments, empathy, and mainstreaming. This resource is largely missing from the examined literature: aesthetics.

Taking into consideration the aesthetics of accessibility does not refer strictly to the display of a technology, although this is as stake as well; an essential focus is on the process of technological design itself, and the people with which we are connected through work. We discuss these dimensions in the following sections.

3.1 Aesthetics and Accessibility of Tools: a Trade-off?

When aesthetics of technological tools are invoked in the reviewed articles about teaching accessibility, they are often presented in a trade-off with accessibility. For example, Wang presents designers' perspective as follows: "Without appreciating the social importance of accessibility, Web designers and developers can hardly be motivated to "burden" their design with accessibility limitations" *(Wang, 2012)*.

Along a similar line, Waller et al. report that "[s]tudents are also asked to examine and discuss the trade-offs between good aesthetic design, sound software engineering and the need for accessibility, for example through mock debates on whether accessibility considerations stifle or spark creativity" *(Waller et al., 2009)*.

These quotes illustrate that the perceived trade-off between accessibility and aesthetic design (Mbipom, 2009) is often not challenged by teachers; professors accept the assumption that accessibility is a potential hurdle for a beautiful (or otherwise aesthetically interesting) design.

From a statistical perspective on the current state of technology, this trade-off may well exist – although there is research that indicates otherwise. For example, Mbipom (2009) analyzed 30 web pages and concluded that those that are perceived as "clean", "clear" and "organized" comply better, on average, with WCAG 1.0, while being seen as "beautiful" or "interesting" does not make a difference. In a similar study (Mbipom & Harper, 2011), the authors analyzed 50 web pages and found that those evaluated as "clean" had fewer accessibility barriers, while the attributes of "pleasing", "fascinating", "creative" and "aesthetic" did not correlate significantly with accessibility.

These correlations are interesting descriptions of the status-quo. Still, they may derive from a general low level of accessibility, rather than from a real independence of accessibility and design. While there are good reasons while cleanliness and clearness associate with higher accessibility, it is possible that the missing correlation between aesthetic sophistication ("interesting", "fascinating", "creative") and access hurdles actually derives from the overall low level of accessibility of all pages under study. That is, if designers do not bother to develop accessible pages and there is a uniform low performance in this respect, accessibility would not correlate with design features because it would not be variable. Low variation can lead to low correlation with any attribute. The challenge remains to cultivate an appreciation for *high accessibility* that accompanies an interest in *cutting-edge aesthetic* design. Cultivating performance simultaneously on these two dimensions raises specific challenges.

Regan (2004) discusses aesthetics and accessibility, diagnosing a "failure of the imagination". He observes that many accessible sites are indeed aesthetically uninspiring and designers ignore access requirements because they orient their work towards inspiring models. There is a need for aesthetically provocative accessible sites, to infuse professional enthusiasm for accessibility in design work. Such enthusiasm is possible, as he found out by observing a team of designers who set out to create an innovative and accessible site: they saw it as a challenge, and engaged it with full energy. Still, initial frenzy led to confusion and deep concern in the following days, as designers began to struggle with the un-visual world of the screen reader. As Regan insightfully notices, designers are visual professionals: they have fine tuned their visual sensitivity and orientation skills for years. Asking them to work in a non-visual environment can easily switch from a challenge to an aggravation. In addition, screen readers are complex applications, which require some familiarity for proper operation, and thus add to the initial vexation. Therefore, engaging designers in accessibility work is not trivial, and not "lightweight": "Designers often spend years honing their instincts for the visual UI. A comparable and parallel effort should be made for alternative environments" (Regan, 2004, p. 37).

Therefore, while respecting the most important accessibility guidelines (such as adding ALT descriptions to visual content, using headings, avoiding unnecessary tables, and allowing for resizeable fonts, among others) is not particularly complicated (although adding captions may come across as tedious and thus 'postponable'), a creative take on accessibility requires a high level of determination to engage with a non-visual environment. Such a creative approach is required in order to transform accessibility from a professional burden to a challenge, and to inspire technology designers rather than to vex them.

Two possible ways to encourage students to think about high accessibility and innovative aesthetics in convergence, rather than in trade-off, are:

- Encouraging a minimalist design aesthetic, based on the "less is more" maxim, and privileging information *structure* and richness of *content* over decoration;
- Emphasizing *flexibility* itself as an aesthetic criterion. Students can learn to understand aesthetics not only through the eyes of sighted persons, but also through the perspectives of screen reader and screen magnifier users, or of color-blind or dyslexic users. Flexibility endows aesthetic value from the possibility of *meaningful use*; there is also an element of *surprise*, as flexibility is not always manifest at a glance.

3.2 The Aesthetics of a 'Job Well Done': Pursuing Technical Mastery

The aesthetic imagination of computer science students can be energized not only in relation to the *tools* they create, but also in relation to their own *work*. The aesthetic value of accessible design as technical wizardry is, we argue, an important motivational resource.

The idea that accessible design is a proof of smart engineering is not uncommon, as we have seen above in the "march of technology" (Rosmaita, 2006) and "technical reasons" (Wang, 2012) arguments. The question is, how to better translate accessibility requirements into a professional challenge for proving technical mastery? This is more a matter of framing and illustrating, than of explicit arguing. For example, the story of dramatically improved accessibility of touchscreen phones brought forward by the iPhone (Tsaran, 2009) displays accessibility-work as *inspirational*, from a design perspective.

The "march of technology" argument is particularly valuable to frame accessible design as savvy design, because it transforms the *limitations* of disability into *opportunities* of technological reach in ever more diverse situations. This can be a starting point for exercises of UX imagination: in which walks of life can we imagine accessible technologies to be attractive to various types of users? How can accessibility turn into expanded usability? If blind users and 'power users' are alike in their strong preference for using key shortcuts (Vuppala & Krishna, 2012), and driving users are for all practical purposes blind to visual information (Rosmaita, 2006), what other similarities can one find across unlike life and work situations?

More concretely, teachers can frame the accessibility designer as a *whiz* by cultivating a professional appreciation for *structure*. Structured design is a strong requirement for accessibility, which is enhanced through clear specification of types of entities (for example, through headings) and by a clear prioritization of content according to its importance. The weakest motivational force derives from framing structure as a requirement of WCAG, a requirement of the law, or a need of a group of users – that is, extrinsically mandated. For a more forceful motivation, the requirement of structure can be framed as an aesthetic criterion of design wizardry, along the following lines:

a) Clear, organized interfaces are highly usable: clarity is a dimension of *beauty*;

b) Structure relates to *depth* rather than surface; understanding how a blind person reads Web pages through assistive technologies that linearize and verbalize content can amount to understanding an alternative, underlying structure of our shared and yet diverging world; the informational structure of visible realities holds a certain aesthetic appeal for computer science students and professionals – as it was maybe best illustrated by the Matrix digital rain (which could be used as a teaching metaphor);

c) Last but not least, an explicit promotion of *minimalism* as aesthetic current would support an appreciation of structured, no-frills design that favors accessibility (Mbipom & Harper, 2011); minimalism has had its ups and downs in web design, for example, but, as Thorlacius argues in his discussion, we can probably agree on a matter of possibility: "A minimalist Web site with no extraneous aesthetics, and visual effects only in the form of typeface and text layout, can be just as aesthetically pleasing as a Web site with lots of pretty pictures and fancy Flash installations" (Thorlacius, 2007, p. 71-72).

An important resource for cultivating aesthetic appreciation for structure in design consists in the experience of *ridiculousness* for poorly designed technologies that mime structure through visual effects (for example, in web design, highlighting headings through font formatting, assembling lists through paragraph formatting, or using tables unnecessarily). As an example of a learning situation in this such humor becomes possible, Benavídez, Fuertes, Gutiérrez, & Martínez (2006) ask students to examine two apparently identical sites, one which is accessible and one which is not. Teachers can create humorous situations that downgrade appreciation for design that is structure-less, tagging it as 'amateurish' or 'lazy', for example. This symbolic fight can then happen again and again when graduates, future professionals, decide consciously or infra-consciously to what extent to structure their technologies, rather than accept older, unstructured versions – which may be already available for revamping, may be easier to delegate to a team member, or may be otherwise more convenient. An aesthetic disregard for 'sloppy, witless work' may counterbalance 'convenience' better than alternative arguments of cost and benefit.

The experiential absurdity of structure-less or otherwise low accessibility design can be brought to life by navigating it through the assistive technologies that blind or low vision people would use. Screen readers' 'non-human voice' (Tsaran, 2009) is often a topic of amusement among those who experience it, as it is its mechanical 'parroting' of everything written (Finke, 2011); at the same time, unnecessary repetition of content verbalized by the mechanical voice of the reader can be not only unhumorous, but downright aggravating (Gerber, 2002).

3.3 Aesthetics of Blind Characters

A third source of aesthetic appreciation of one's work in accessible design could derive from a feeling of working in connection with blind people, end users and most direct beneficiaries. The question rises, how can empathy and a feeling of sharing experiences across different life worlds be better produced, and turned into an aesthetically valuable experience?

3.3.1 Representing Blind Users

The issue of representation of blind people for sighted students is concomitantly challenging and relatively under-discussed in the literature. As we have seen, teachers of accessible design do stress the importance of meeting blind people and witnessing their experiences of technology, either through lectures or through collaboration. Such encounters generate many insights into the specific worldviews and experiences of blind persons – bringing forward both their problems and their skills and achievements, often unimagined by able students who are not familiar with disabilities.

We propose that such encounters can be consolidated, as an experience, by adding opportunities for explicit reflection on the diversity of blindness, the shared-and-disparate worlds in which sighted people coexist with blind people, and the almost unimaginable skills that blind people develop to master the world.

Sighted students and sighted persons in general are often deeply impressed when meeting blind people, and when their preconceptions are confronted with real lives and actions. At the same time, experiences of direct interaction can be enhanced by mediated interplay.

Firstly, if direct interactions are not reflected upon and if they are not elaborated into *narratives*, their memories may fade, and their value for out-of-classroom work, which is our focus, declines as the years go by.

Secondly, there is often a limited number of blind people that a sighted student will be acquainted with personally, through her or his University experience or otherwise; while knowledge can be deep, there will remain a certain limitation in breadth, concerning the variety of life situations encountered.

Last but not least, given the extraordinariness of some of these experiences, sighted students may be at some loss of how to *make sense* of what they have observed, in an *existential*, rather than a behavioral way. What do the actions and interactions they have been part of tell about human nature – about the diversity or similarity of life situations, the capabilities and limitations of people, the power of individual and the power of relationships or of technologies? There is an important work of sense-making and conceptualization, which is the topic matter of disability studies, which should be at least touched upon in order to reach the full knowledge and motivational potential of such encounters. While there may not be time enough for a familiarization of students with theories of disability, one could probably find some intervals for a more informal exploration. In the following section we aim to indicate some *online resources* for this work of sense-making, through which blind users become *strong characters*, sharing the world and the work with skilled technology designers.

3.3.2 Online Encounters

Based on the reviewed literature, it seems that introducing online blind characters to visually able students is a rarely used resource for teaching accessibility. Still, there is a rich blind presence on the Web; as it is to be expected, there is no shortage of narratives, shared experiences, and opportunities for digital interaction.

Online characters can complement meeting blind people face-to-face in at least two respects. On the one hand, there is the *narrative richness*: there are many deep, insightful, detailed online written accounts of living with blindness, ranging from several paragraphs to book length; they offer students vocabularies for making sense of this condition of being in the world. On the contrary, University-mediated encounters with blind people are often limited in the amount of interaction they can afford for individual students, and in the diversity of topics touched in conversation and narration. On the second hand, there is the *diversity of life situations*: we can digitally reach people who are blind students, parents, IT professionals, teachers, unemployed, artists and so on; these identities are, of course, overlapping, but usually some of them will be more prominent in a given account.

Online encounters with blind characters are an apt method, for teachers, to reverse the dominant framing of blind persons as needy, vulnerable, and incomplete. Students can experience in so many instances the frustration of blind people when being treated as partially human - illustrated, for example, by Atkinson (2007): “Misconceptions start to spout from even your oldest friends' mouths because negative attitudes about blindness permeate us all. You are about to cross over into the dark side and see what wriggles and writhes on the underbelly of society. Folk will see you as the sufferer, the pitiful, the afflicted, the subhuman – that's you, yes, you. If you use a cane or a dog, people will stare as you walk down the street. People will assume you are more lacking in intelligence than your sighted counterpart. People you have never met before will ask if you want children, and if you do, they will ask if the kids will have the same condition that you have, and whether that is right or wrong. Welcome. Your reproductive autonomy is in the docks of the moral courts of the nation's minds. (…) Going blind (...) is a grand experiment that most don't get to try: to observe as your brain rewires and watch as the human body adapts in infinite ways" *(Atkinson, 2007)*. Online encounters facilitate a gradual re-definition of blindness from 'lack' and biological 'disease' to a condition in life that is strongly shaped by how it is defined and acted upon.

The tropes of extra-ordinariness and *heroism* are very important for making sense, as a sighted person, of blindness; the online environment offers access to many blind characters with extra-ordinary achievements that impress others through their strength, unimaginable skills, and wisdom. It also introduces characters that are ordinary in every respect lest of being blind, and it also introduces characters that are confused, overwhelmed, or otherwise vulnerable; therefore, there is a wider range of emotional responses that the sighted observer or interlocutor could experience.

The online environment also offers a different kind of *facility of interaction*. Blindness is often experienced, by sighted users, as a *stigma* – as an embodied feeling that the interaction flow is collapsing, awkward or otherwise difficult. The following account of a blind person renders this obstacle intelligible: "There is an invisible wall between the sighted and the visually impaired," Ms. Squarci said. "One of the women I interviewed, she has been blind since she was 4 years old, she told me sighted people are almost scared to deal with the blind. Being blind is like speaking a language. If sighted people don't find eye contact – which is the first hint of communication – they feel lost and they don't engage" (Gonzalez, 2013). The online environment allows sighted users the comfort of timing interaction as they see fit, also unidirectionally or asynchronously; of taking time to get acquainted to visually disabled portraits without the anxiety that one might reveal discomfort and therefore appear as prejudiced and socially unskilled. That is, the online medium can be used as a training ground, a *sandbox for interaction* between sighted students and blind people. This could also provide students the opportunity on reflecting on their emotions when encountering blind people online, helping with the emotional work required for successful interaction in all social situations.

A very specific resource facilitated by the online environment refers to the *aesthetics of blind faces*. The discomfort of sighted people when looking at a blind person can be confronted and strongly challenged by visiting online exhibitions of *visual portraits of the blind*, such as, among others Gaia Squarci exhibition (Gonzalez, 2013); Sam Ivin Photography (Ivin, n.d.); Julia Fullerton-Batten, Blind (Fullerton-Batten, n.d.); Charlie Simokaitis, Fade to white (Simokaitis, n.d.).

Through online exploration and ventures, various dimensions of interaction between sighted and blind people could be touched: the *humor* of blindness, through its many mishaps, including the ill-suited reactions of sighted people; its *absurdity* and, conversely, its capacity to highlight *meaning* in life; its malleability in being experienced as a *disability*, as a *repertoire of skills*, or as utter *normality*, depending, among others, on the tools and relations that constitute the capability of any human being from the perspective of distributed, 'person-plus' (Perkins, 1993) competence.

3.3.3 Blind Personas in Learning Practice

Teachers may dispose of anything from several hours to semesters of study for introducing accessibility, depending on the learning context. Blind *personas* (Johansson & Messeter, 2005; Pilgrim, 2002) are a flexible tool to acquaint students with the aesthetics of accessible design and to evaluate their learning and motivation. Students can participate in individual or team projects to construct and present blind personas as users of specific technologies, highlighting relevant background aspects of their lives and concrete details of their experiences with technology. Personas can be sketched in a couple of hours or portrayed through in-depth research, depending on available time. A *persona* offers a rich ground for expressing the aesthetics of blind characters, accessible tools, and accessible design. Personas are also useful tools for design in general, beyond accessibility concerns. Such learning projects take advantage of the variety of students' aesthetic preferences and professional interests as a resource for collaborative learning about the diversity of blind people's life experiences and technology use.

4 CONCLUSIONS

We analyze the literature concerning accessibility in the computer science and engineering curriculum, focusing on the repertories of arguments and practices that authors put forward to support students' motivation. We find a persistent concern for *arguing* with students and readers that accessibility is a reasonable, efficient, moral and ultimately legally required pursuit. We also identify *empathy* and *mainstreaming* as two motivational drives distinct from the logical 'web of arguments', instilling the interest for accessibility in emotions and routines.

We propose an additional resource to consolidate students' persistent motivation: an *aesthetic* appreciation of accessible tools, of working with accessibility in mind, and of characters of blind people – the direct beneficiaries of these pursuits. We advance a first version of an aesthetic motivational repertoire, including arguments, practices, and online resources. Students' construction and presentation of *blind personas* is a flexible and useful learning tool to this purpose.

Harrison (2005) writes, reflecting on her teaching: "If students are given the challenge of designing an accessible site, they will rise to meet that challenge" (p. 26). An aesthetic imagination could make this venture even more engaging.

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Using a Participatory Design Approach to Create and Sustain an Innovative Technology-rich STEM Classroom
One School's Story

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Abstract: This paper describes the design and implementation of a technology-rich STEM classroom in a secondary school associated with a comprehensive U.S. Midwestern university. Built to address a waning interest in STEM and STEM careers, this classroom offers multiple technologies and an engaging, flexible physical space that together create an innovative learning environment. A participatory design approach was utilized in order to maximize the use and sustainability of the classroom. Students, teachers, and administrators from the secondary school worked in collaboration with university faculty and staff and with Herman Miller®, an international design company that conducts learning-space research. In addition to the design process, this paper outlines successes and challenges encountered in implementation, as well as strategies used in addressing the challenges, providing guidance for other educational organizations seeking to infuse advanced technologies into classroom design and instruction.

1 INTRODUCTION

In February 2012, McCoy High School (pseudonym), a public high school in the U.S. Midwest, opened a high-technology classroom designed to be an innovative environment for teaching and learning in science, technology, engineering, and mathematics (STEM). This STEM classroom was created in response to a call for an increasing focus on STEM education in U.S. schools, as articulated in several high-profile national reports (National Research Council, 2011; National Science Board, 2010; PCAST, 2010). These reports emphasize that STEM education is the foundation for many of the high-growth sectors of the economy. In response to these reports and to a growing number of federal and state initiatives, local school administrators and teachers are looking for practical solutions to enhance the quality of STEM instruction, and this issue is not limited to the U.S. (Berguard et al., 2012; Joyce and Dzoga, 2011; Marginson et al., 2013).

Many schools are turning to computing technologies as a means to improve STEM education because there is a growing consensus that students should be exposed to the advanced technologies and tools used by practicing scientists and engineers (Cohen and Patterson, 2012). McCoy's STEM classroom provides students who are living in an urban, high-poverty community with access to some of the latest technologies and tools of STEM as part of their learning experience, with the long-term goal of raising student achievement and inspiring students to pursue STEM university degrees and careers. The classroom incorporates design elements that reflect recent understandings of effective ways to promote and support STEM learning, and includes features that the STEM teachers and students feel are important for facilitating learning.

In this paper, we describe the design, development, and implementation of McCoy High School's STEM classroom. We discuss some of the challenges encountered during the process, including approaches taken to meet these challenges, and finally highlight factors contributing to the success of the project.

2 BACKGROUND & VISION

The newly constructed STEM classroom is a part of McCoy High School, a public high school located within the local city public school district and sponsored by a nearby public university. The school is located in an economically depressed, post-industrial, Midwestern city which is part of a large urban metropolitan area. All of the school's 115 students are African-American, and approximately 90% of students are eligible for free or reduced-price lunches. The school has limited resources and, prior to construction of the STEM classroom, had access to only two outdated computer labs that often were not fully operational. The school recently completed a third year on academic watch. In the United States, a school is placed on academic watch if it does not meet proficiency performance standards in academic, attendance, and graduation rate targets defined by the state for four consecutive years.

Students in districts with a high poverty level are especially at risk of being unprepared for university science and mathematics courses (Darling-Hammond, 2010). As students advance in grade level, mathematics and science test scores markedly decline. In the McCoy High School district, only 47% of 7th graders and just 8% of 11th graders meet performance standards for science on state examinations. Furthermore, schools in low-income communities often do not have the materials, laboratories, and equipment to teach mathematics and science effectively, and many teachers lack the necessary training in their subject areas.

In early 2011, the university received a large donation to design and construct a high-technology STEM classroom at the high school, with some of the funds designated for teacher professional development and onsite technology support personnel. The university's STEM Center was charged with overseeing the classroom's design and construction, and it played a key role in gathering together the design team and establishing the project's vision.

The overall vision for the new classroom was developed by experts in STEM education at the university. The stated purpose of the new learning space was to provide students with access to state-of-the-art technology, equipment, and curricula and to support teachers in providing students with hands-on, minds-on science learning. Then, taking a wider view, the team envisioned the classroom as a resource for the entire school district and as a model for excellence in STEM education far beyond the local setting.

The largest portion of the classroom was viewed as a "learning studio," in which movable, flexible seating would enable group work and student-centered discussion. Integrated into the physical space would be state-of-the-art computing and communications technologies and scientific equipment, providing opportunities for authentic learning rarely afforded in low-income communities.

The team also proposed a separate, smaller facility adjoining the main classroom, modeled after the fabrication laboratory, or "FabLab," concept. Originating at the Massachusetts Institute of Technology, educational FabLabs allow students to design objects on a computer using CAD software and then see their creations printed in three-dimensions. FabLabs enhance the learning of a variety of subjects ranging from geometry to engineering, to art and design, and help students see the connections between STEM and the creative process (Blikstein, 2013). Another goal for the space was to enable teachers to move easily between the main classroom and fabrication area as needed to ensure student engagement and achievement of learning goals.

A final, yet essential, component of the project was the provision of teacher training and support to ensure that the STEM teachers would be fully empowered to integrate the new resources into their teaching. It was intended that university faculty, master educators, and an on-site educational technology specialist would work in partnership with the high school teachers over an extended period of time to ensure that the technology and equipment would be used effectively and with the greatest benefit for student learning.

3 DESIGN PROCESS

The design process for the STEM classroom was participatory, using input from multiple units within a university, business representatives, and the ultimate users of the space, the school's teachers and students. Participatory design was initially introduced in the design of computer systems and technologies in the early 1970s. Today, the concept of participatory design is more flexible and applicable in a range of fields employing a variety of techniques (Crabtree, 1998). A major constant in participatory design is the involvement of users in the design process. According to Baek & Lee (2008, pp. 173), "a participatory design process relies on the collective generativity of stakeholders; in other words, it uses the collective ability of stakeholders to generate or create thoughts and imaginings."

The classroom design and construction involved a large team of individuals representing several units of the university and three businesses. The university's STEM Center director articulated the vision for the space through team meetings, and each unit took responsibility for different aspects of the design. The university's Instructional Technology Services (ITS) assigned two representatives to develop plans for configuring the room to maximize the use of computing technology. Installation of computer projection and videoconferencing systems and networking capabilities was completed by an outside contractor. The university's Facilities Management assigned an architect to design the physical space and to manage the construction schedule and work of carpenters, painters, and electricians.

At an early stage, the university contacted Herman Miller®, known for their innovative furniture designs and interest in research on learning spaces, to request that the project become part of Herman Miller's Learning Studio Research Program. Consequently, McCoy High School became the first secondary school accepted into this program. This formal partnership brought additional resources to the project including interior design expertise. Herman Miller® and an interior design company worked with the project team to turn the vision into reality, providing possible room plans, furniture options, and color schemes.

The participatory design process ensures that all users play a meaningful role in the design as "either an informant or co-designer" (Bowen, 2010) in order that the end result will better meet their needs and uses. Diverse perspectives, especially those of teachers and students, are important when designing educational environments (Könings et al., 2007). According to Woolner (2009, p.15), "Importantly, it seems that the potential for longer term influence is bound up with recognising and understanding the inextricable linking of actor and setting, as this applies to the wide range of school users throughout and beyond the period of change. If this shared understanding can be developed through participatory design, this should satisfy the needs of architects and educationalists (e.g., Dudek, 2000 and Clark, 2002, respectively) who have called for more involvement of users in school design and recognition of the practical contribution of the physical setting to teaching and learning."

Thus, a critical aspect of the process of designing the STEM classroom involved participation by its end users. The school's three STEM teachers and six student representatives provided feedback on their needs and their vision for an effective learning space. Meetings of the STEM Director and the high school team explored teachers' and students' opinions on everything from the educational activities that would take place in the space to possible designs to the aesthetics and feel of the learning environment. Feedback was summarized and conveyed to the larger group and incorporated into the design whenever feasible. A summary of key comments from the teachers and students is shown in Figure 1.

Space and Furnishings
- Colorful
- Bright lighting
- Movable furniture for flexible seating arrangements
- Café-height chairs

Technology
- Work spaces for robotics and other design tasks
- High-speed wireless
- Many electrical outlets
- Separate printer room to reduce noise levels
- Experimental technologies
- Durable equipment

Teaching Environment
- Communication is facilitated by multiple writing surfaces
- Open spaces to move in and form student groups
- Option of two instructors/classes in the room simultaneously
- Respectful attitude towards the room and equipment

Figure 1: Teacher & Student Comments.

Four overarching principles guided the design team and are reflected in the final product:
- Fosters creativity and innovation
- Meets the needs of the school
- Appeals to students and teachers
- Integrates innovative technologies

The next section focuses on how these principles are reflected in the final design of the classroom.

4 CLASSROOM FEATURES

The overall design of the classroom encourages student-centered instruction and group work. The room contains a variety of tables and chairs that are easy to reconfigure for large and small group activities. Movable whiteboards and writable walls provide a large amount of writing and design space (Figure 2).

Figure 2: McCoy High School STEM Classroom. Photo courtesy of HermanMiller®.

Computer and information technologies are central to this learning environment (Figure 3) and can be easily configured for independent and group projects. Laptop computers and tablets can be plugged into the network via floor ports in multiple locations throughout the room, and in turn can be projected onto one of several screens. Additional technology features of the room include a four-screen video wall, an LCD SMART Board, 52-inch TV monitor, HD document camera, and ceiling-mounted video cameras to record classroom activities. Sets of iPads, laptops, Botball robotics kits, a programmable humanoid robot, TI-Nspire calculators, and student response systems are available for individual and collaborative work. Additionally, the FabLab contains a 3-D printer and computers with design software to enable students to work with engineering design projects.

The first meeting to begin the design process was in April 2011, and the ribbon-cutting and official opening of the STEM classroom took place in February 2012. In late 2012, The Educational Interiors Showcase awarded the STEM classroom one of its top awards for classroom design, noting the space's "good use of technology" and its "variety of collaboration/presentation spaces and seating options within the classroom."

- Laptop computers
- iPads
- Graphing calculators
- Robotics kits
- Humanoid robots
- Digital cameras
- Document camera
- Multiple flat panel displays
- Video wall
- Classroom recording system
- High definition video conferencing
- 3D printer
- Large format printer
- Desktop computers with 3D design software

Figure 3: STEM Classroom Technologies.

5 IMPLEMENTATION

Teaching practice is a product of both the teacher and the teaching environment (Wilson, 2011). Once the room design was completed and construction started, teachers began to consider the question of what they needed to learn in order to make effective use of the new technologies for teaching and learning. They realized that using the technologies within the new space could not only impact current practices, but would require teachers to be open to changing the way they currently teach.

5.1 Researching the Implementation

In conjunction with the design and implementation of McCoy's STEM classroom, researchers from the University's STEM Center designed a research study to understand and document how the STEM teachers capitalized on the potential of the space and available technologies to adopt new or modify existing pedagogical strategies. The research explored factors and challenges that influenced when and how teachers use the room and its technologies. This included examining teachers' concerns and attitudes about using the space over the course of its implementation. It was hoped that findings from this research could be used to optimize the usability of the learning space.

Because of the uniqueness of this complex and dynamic setting, the researchers chose a single case-study design with mixed methods of data collection and analysis. The intention in using this design is that the story developed may provide unusual insights that challenge or reinforce a reader's existing beliefs and promote broader understanding of the issues involved (Patton, 1990; Stake, 1998; Yin, 2009).

Two of the math and science teachers at the school agreed to participate in the research study. Initially, the study followed three teachers; however, one of the teachers left McCoy High School shortly after the research study began. Demographically, the two teachers who are the focus of the study are very different. Teacher A, an African American female in her 60s with extensive experience as an IT professional, participated in the design meetings. She had taught for five years at McCoy High School at the time the room was designed. Teacher B, a Caucasian male in his 20s, also participated in the design meetings. He recently had been hired and began his first year of teaching during the year the room was constructed. In addition, two key administrators at the school agreed to participate through interviews, and 30% of the students agreed to participate through focus groups and by completing surveys about the features of the room, the technologies, and their teachers' teaching styles.

Data sources include guided and open-ended interviews with teachers and administrators, student focus groups, and observation of sessions in both the STEM classroom and in regular classrooms. Additional data that inform the study were gathered from survey instruments including pre and post student and teacher questionnaires designed as part of the Herman Miller® Learning Spaces Research Program and periodic administration of the Stages of Concern Questionnaire (SoCQ) (George et al., 2006) to STEM teachers. SoCQ is used to create profiles of individuals' evolving levels of concern throughout the process of adopting an innovation.

The data enabled the researchers to identify challenges encountered by the teachers when using this new space and when incorporating new technologies and pedagogical strategies into their teaching. The following section identifies these challenges along with ways these challenges were approached.

6 CHALLENGES TO IMPLEMENTATION

1. *Lack of Familiarity with Many of the Technologies Available and ways they might Effectively be Integrated into Teaching*

Approach: Numerous researchers have identified teachers' confidence and skill in using technologies combined with ability to see value in using technologies as major factors influencing teacher adoption of available technologies (Bingimlas, 2009; Buabeng-Andoh, 2012; Gaffney, 2010; Mumtaz, 2000). One way to build teacher confidence and skill is through professional development. Effective professional development is ongoing, uses peer coaching, and includes teachers in planning activities (Garet et al., 2001; Gulamhussein, 2013).

At McCoy High School, professional development began during the construction phase and continues today, with the STEM teachers playing a leading role in identifying the type and pace of the activities. Because of other demands on their time, the teachers asked that training focus on one new technology at a time. This would enable them to become familiar with the technology and consider how best to use it with students.

The teachers visited other schools' high-tech classrooms and participated in national conferences, such as the National Science Teachers Association (NSTA) and International Society for Technology in Education (ISTE), as they sought ideas for using the new technologies in their own teaching. Vendor demonstrations occurred, and teachers were given iPads to familiarize themselves with the technology and begin to plan how they might use them in teaching. Teachers from other schools who were experienced with particular technologies led hands-on sessions to introduce teachers to new technologies, such as TI-Nspire graphing calculators and 3-D printers, and shared information on ways they use the technologies with students. An education faculty member from the university worked with the teachers to develop and test lessons incorporating the new technologies and features of the space. Teachers observed and critiqued the lessons for each other. These master technology teachers along with university personnel are an ongoing resource for the teachers.

2. *Need for Regular Communication Among a Diverse Group of Stakeholders. Stakeholders Included the School Director, STEM Teachers, University Personnel and Researchers*

Approach: According to Rogers (1962), effective communication channels play a central role in the diffusion of innovations. Communication and sharing of information among the stakeholders involved in the implementation phase proved at times to be problematic as other responsibilities and duties took precedence and delayed email or phone responses. To ensure that all stakeholders are informed on issues related to use of the STEM classroom, periodic meetings occur with key school administrators, STEM teachers, STEM Center director and researchers, and a representative from the University's education department. Albronda, De Langen, and Huizing (2011) report that group meetings appear to be an "effective means of informing and interaction" among stakeholders during adoption of an innovation. The meetings, which are ongoing, provide an opportunity for sharing information, celebrating successes, discussing issues specific to the STEM classroom, planning ways to address STEM teachers' professional development needs, identifying teachers' needs with respect to the STEM classroom and the technologies, scheduling research observations and interviews, sharing of school initiatives by school administrators, and discussing how teachers are using the space and technologies.

3. *Limited Technical Support*

Approach: "Because technology is inherently unreliable and can break down at any time, teachers may choose not to use it in their teaching unless there is a strong need for it and reliable support" (Zhao and Frank, 2003, p.809). Although teachers and school administrators had input regarding the choice of technologies for the space, the university completed the purchasing and installation. As the teachers began to use the technologies during their first year in the new space, Teacher B, who had a reputation for being able to fix technology problems, assumed the role of technology support person in addition to his teaching responsibilities, and described this role as a "burden." However, during the second year, the university hired a part-time technical support person--again with teacher input--to keep the equipment running and provide just-in-time assistance when the classroom is in use.

4. *Classroom Management Issues*

Approach: A major concern of the teachers was how to handle behavior problems and prevent damage to the technologies in the new space. One teacher addressed this by only bringing upper division students into the space during the first year and limiting the features and equipment that could be used. The teachers developed some general rules that all users agreed to abide by with respect to putting technologies properly away at the end of sessions and keeping the space clean. Participants in student focus groups described how they felt responsible for keeping the room and the equipment in good condition. One student responded to the question, "Who takes care of this room?" by saying, "I feel like we all do. I feel like it's a community effort... everybody kind of contributes to cleaning up the room."

5. *Equitable use of the Space*

Approach: As STEM teachers began to bring their classes into the new space, concerns developed around the fair and practical use of the room. Even though a listing of time slots was made available as a sign-up sheet on Google Docs, one teacher tended to monopolize the schedule so other classes were rarely able to use the room. If a time slot was empty, other STEM teachers would often move their classes in without signing up, resulting in two classes arriving at the room at the same time. Together, the teachers developed a protocol to ensure that each student in the school uses the space and its technologies at least once a week, and that every STEM class has a lesson taught in the classroom every week. They devised a better way of scheduling their time in the classroom, and even found ways for two classes to occasionally use the space simultaneously. Also, technologies such as iPads, laptops, and calculators can be used in a teacher's regular classroom when not needed in the STEM classroom.

6. *Professional and Personal Concerns*

Approach: The time required to keep up with rapid changes in technology is an important factor in its use (Zhao and Frank, 2003), and teachers often worry about how to do this in addition to their other teaching duties. For example, Teacher A identified "other responsibilities/priorities and time to learn" as major obstacles to implementing new technologies. There also appeared to be a question of what personal value the new technologies would have. "Personal feelings of uncertainty, whether one can succeed with this innovation, and whether the supervisor will support the efforts," are common concerns of teachers faced with adopting an innovation (Hall, 2010, p. 243). Teacher B found balancing responsibilities of being a first-year teacher, assuming the role of the school's IT specialist, and exploring what teaching with new technologies would require from him to be challenging.

Several aspects of the implementation process addressed these concerns. First, the school provided time and substitute teachers, giving the STEM teachers opportunities to visit other high-tech schools and to attend conferences. Other events such as an open house and various newspaper articles celebrated the STEM classroom and its success, giving the teachers and students a sense of pride.

Teacher A commented, "There's a lot of visibility... I think kids were proud to see us in the paper. I think it's always good to highlight the good, and so I think that overall it's been a really positive thing. I get more positive all the time."

7 DISCUSSION

Using a participatory design process that included students as well as teachers has led to a sense of ownership of the room by both groups. Teachers and students depict traditional classrooms as 'teacher space' while they view the STEM classroom as 'community space' with both teachers and students equally responsible for maintaining the room. In focus groups, students enthusiastically discussed how pleased they were to see their suggestions integrated into the actual classroom along with ideas they had not even considered, such as the video wall. On their own initiative, they have created projects relating to the use of the room and its technologies as a "legacy" for future students.

One major aspect of the room that both teachers and students praise is the room's flexibility. The furniture can easily be rearranged to accommodate different teaching styles and activities. Students appreciate being able to display their work in different ways using a variety of devices. Teachers regularly comment on students' pride in the room and how being in the room seems to positively affect students' willingness to stay on task and learn.

The room appears to be having an impact on teachers' teaching style as well. Teachers describe their teaching approach in the STEM classroom as being 'less dictatorial' and more relaxed than when they are in a traditional classroom. One STEM teacher who had been somewhat reluctant to use the technologies in the room observed that anticipated classroom management problems did not materialize to the extent expected. Consequently the teacher became more open to identifying technologies in the room that might be used next in teaching. In the STEM classroom, this same teacher encouraged students to learn new features of technologies and share their expertise. The other STEM teacher described how having so many different technologies available made it easier to accommodate students' different. Although the teachers are not yet using all of the available technologies, it is anticipated that all will be in use by the end of the second year in the room.

The design and implementation process for the STEM classroom is ongoing. Often stakeholders' involvement ends once construction has been completed. However, an important aspect of the process described in this paper is that university and STEM Center personnel continue to be actively involved during the implementation phase in a variety of ways, including participation in the periodic meetings, facilitation of professional development requests, and continuation of the research study. The presence of a technology specialist has alleviated technological problems and allowed the teachers to focus on ways to integrate the technologies into teaching and learning. Administrators and STEM teachers continue to identify additional resources needed in the room and in their professional development. The room itself was not designed to be static, but rather to continue to evolve as users experiment with different ways to teach and learn in the space. The presence- of mobile technologies in particular will enable upgrading the technologies as newer devices become available.

One final consideration is the importance of leadership. Byrom and Bingham (2001) identified strong, supportive leadership as one of the most important factors in teachers' willingness to adopt innovations. The leadership role played by stakeholders from the university--especially the Director of the university's STEM Center--was crucial during design and construction of the classroom and continues during implementation.

The leadership of McCoy High School also played an important role. The construction and implementation coincided with the appointment of a new director for the school. In discussing the room, the director stated that continued student input would be very important to the success of the room. She stressed to the teaching staff that because the room contains the best and the latest of technologies, activities within the STEM classroom should be project-based, utilizing the technologies and features of the room to the fullest. She emphasized the importance of seeking out appropriate professional development to achieve this goal. Throughout the implementation process she has encouraged the teachers to decide how best to use the space and technologies and to play a major role in designing the content and pace of their professional development. She has arranged substitute teachers when these activities conflicted with their teaching schedules.

The director takes great pride in the room and has made it integral to setting future priorities for the school. She has been instrumental in publicizing to parents, community members, media and university personnel what teachers and students are accomplishing in the room. In describing the impact on the students, the director said of the STEM classroom it will "...change lives. We have an advantage of educating minority and underprivileged students with this advanced technology. They are going to have more options because of the STEM experience at the high school level."

The successful implementation of a technology-rich educational environment requires a participatory process that doesn't end when construction is complete. Keeping the stakeholders actively involved and attending to the concerns of the teachers and students greatly increase the usability and sustainability of this type of project.

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SHORT PAPERS

International eLearning
Innovation in Practice

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Keywords: Distance English Language Learning, Online Learning Models, International eLearning.

Abstract: The global demand for higher education cannot be met through traditional structures and delivery methods or by adhering to elitist and cost-prohibitive paradigms. Tertiary education through distance delivery provides opportunity for individuals to recognize their potential and improve their life conditions. Innovative approaches to distance learning can remove barriers and support access for a range of learners. This study reports on findings from an intrinsic case study of two institutions. These institutions have developed eLearning models that provide global access and address the needs of diverse learners. An understanding of these models can contribute to innovative practices at other institutions.

1 INTRODUCTION

"Higher education is almost universally recognized as the means to a better quality of life," (Andrade, 2013, p. 66). Education decreases poverty, results in healthy lifestyles, and promotes civic engagement (Baum & Ma, 2007; Carneiro and Steffens, 2006; International Council for Open and Distance Education [ICDE] & European Association of Distance Teaching Universities [EADU] 2009). As such, nations that have traditionally reserved tertiary education for the elite are increasing access (Kamenetz, 2010; Trow, 2005).

Educational providers can extend their borders nationally and internationally through distance learning. The latter provides educational opportunity to underrepresented groups, improving social equity (White, 2003). "It is inclusive, reaching individuals previously marginalized to change lives and improve communities and economies" (Andrade, 2013, p. 67). This intrinsic case study explores online learning models at two U.S. higher education institutions to determine how they extend global educational opportunity.

2 LITERATURE REVIEW

Brick and mortar institutions cannot meet demand (Hanna, 2013; Gourley, 2006; Kamenetz, 2010). Challenges to expanding access include capacity, resistance to change, structural barriers, and cost. Many traditional higher education institutions adhere to time-honored delivery methods and have only recently begun to recognize and address the need to deliver education in new ways to new audiences. Although chief academic officers recognize the necessity for strategic thinking related to online learning, faculty are slower to accept its value and purpose (Allen & Seaman, 2013). Systems are often unable to adapt, incorporate new technologies, or offer effective distance learning support. Affordability is another obstacle. Often those who need education the most can least afford it; increasingly, the return on investment for higher education is in question (Kamenetz, 2010; Carlson, 2013; College Board, 2012).

Populations driving the demand for higher education may have distinct academic and socialization needs related to academic preparation, technology, knowledge of higher education culture, and, in some cases, English language proficiency. These factors may cause learners to lack confidence in new learning situations and impact their success. Course designers and instructors must consider the needs of global learners related to technology, culture, pedagogy, communication, English proficiency, and learning approaches (Andrade, 2013). Innovative models are critical to helping new populations of learners succeed.

As English is the medium of instruction for much educational content, proficiency in that language is a prerequisite for realizing the benefits of higher education in both traditional and distance modalities (Andrade, 2013). However, distance foreign languages courses have developed more slowly than those in other disciplines (Hurd, 2006) due to the need for interaction, specifically input and output. Language learners need to read and listen to the target language and produce language, negotiate meaning, test rules, and get feedback (Krashen, 1985; Swain, 1995; Long, 1996).

An equal balance of meaning focused input, meaning focused output, language focused instruction, and fluency development is critical to an effective language course (Nation, 2001). While meaning focused input (i.e., understanding readings, lectures, and conversations), some aspects of meaning focused output (i.e., communicating through writing), language focused instruction (i.e., studying grammar, vocabulary, and pronunciation), and some features of fluency development (i.e., using familiar vocabulary and grammatical structures for reading, writing, and listening,) lend themselves to distance learning, other aspects, such as social interaction, require innovative approaches and application of technology (Andrade, 2013).

Non-native English language speakers with aspirations for further education not only need the opportunity to develop academic English skills preparatory to enrolling in distance courses, but also benefit from socialization to educational expectations, which differ by culture, and the development of attributes for success in distance learning contexts. Although the same is true for many students, the specific linguistic, academic, and cultural support requirements of non-native English speakers has been well-established (Andrade, 2008; Gunawardena, 2013; Holta, 2013).

In addition to language acquisition theories, distance education and learning theories are also relevant, specifically as they relate to helping learners succeed. The theory of transactional distance explores the relationship among structure, dialogue, and autonomy (Moore, 2013). Transactional distance is the gap between the learner and the teacher in a distance course. The basic tenet of the theory is that when structure and dialogue are high, autonomy is low. When structure and dialogue are low, autonomy is high. Structure consists of the materials, assignments, due dates, and other built-in design elements of a course while dialogue reflects interactions among students and teacher. The latter may include email, feedback, announcements, and live conferences. Autonomy refers to both choice and capacity—the learner's freedom to choose what, when, and how to learn, and the learner's ability to be self-directed (Moore, 2013).

Related to autonomy is the concept of self-regulated learning, defined as learners taking responsibility for the elements that affect their learning (Dembo & Eaton, 2000). It consists of six dimensions—motive, methods, time, physical environment, social environment, and performance (Zimmerman, 1994; Zimmerman & Risemberg, 1997). Self-regulation behaviors can be taught and can help students improve their achievement. The concept has been specifically applied to English language learning, both online and face-to-face (Andrade & Bunker, 2009; Andrade & Evans, 2013). As learners consider their reasons for learning, methods and strategies, use of time and priorities, where they study, how and when they seek help, set goals, reflect on their performance, revise their goals, and make changes, they increase their capacity for learning and autonomy. The teacher acts as a facilitator. The result is a learning-centered rather than a teacher-centered experience.

These elements must be carefully considered in terms of course design and learner support for international eLearning. "Development teams must understand diverse learner characteristics and design pedagogical environments that address learner goals and aid achievement" (Andrade, 2013, p. 69). The case studies in this research examine these factors.

3 METHODS

This is an intrinsic case study in which the case itself is of interest due to its unique nature (Stake, 1995). Case studies are appropriate when the research addresses the questions of *how* or *why* (Yin, 2003). In this study, the focus is on *how* two institutions successfully developed programs to address the needs identified in the literature review—global access to higher education, affordability, and support of diverse learners, particularly in terms of English language proficiency. The purpose of an intrinsic case study is to understand the case rather than an abstract phenomenon or to establish a theory or new methodology (Stake, 1995).

As established, a clear need exists for global eLearning to provide access and support the success of non-native speakers of English with a range of educational, cultural, linguistic, and technological backgrounds. The two institutions selected for the study illustrate how this need can be addressed. As such, this is a collective case study that examines the similarities and differences between the programs

(Yin, 2003) to better understand how the models respond to international contexts and student populations. The unit of analysis is the two programs (Miles & Huberman, 1994).

Data was collected from websites, teacher training materials, courses, and teacher and learner experiences. The researcher's involvement with course design and teacher training at one institution and teaching online English language courses at both institutions provided direct interaction with learners and teachers over two years and involved approximately 230 students and 56 teachers. Data also involved one-hour telephone interviews with an administrator at each institution, and multiple interactions with approximately six course supervisors. Administrator interviews focused on vision and goals, admission and costs, delivery models, and enrollment. The interviews clarified other data sources and provided additional details and insights. The sampling was purposeful in that it drew from a variety of sources to better understand the programs. Multiple data sources and the researcher's prolonged exposure to the programs triangulated the findings.

The initial conceptual framework consisted of examining institutional contexts and program components (e.g., purpose, target audience, admission standards, cost, course design, matriculation requirements, etc.) to determine how these components supported global higher education access, affordability, and learner support. The framework continued to develop with the data analysis (Miles & Huberman, 1994); as the components were explored, the themes or categories further emerged demonstrating specifically how the programs worked in practice.

The study is limited in that it focuses on only two institutions and is qualitative; however, although findings of this type of study cannot be generalized, the reader can determine if they are applicable to other contexts (Baxter & Jack, 2008). An additional limitation is researcher bias as the researcher was involved in course design and teaching; however, care was taken to monitor this as data was collected and analyzed. This was accomplished by objectively examining institutional practice through the lens of the literature and the conceptual framework.

3.1 Context

Both institutions are private, undergraduate institutions in the United States. They are referred to as Institution Self-Regulated Learning (SRL) and Institution Prepare, Teach, Ponder (PTP) to reflect their respective online learning models.

Institution SRL has a total enrollment of 2,600 students of which 44% are international; of these, 230 students are enrolled in online courses. Data is not available to indicate how many of the latter are international although administrators indicated that the majority are. Online enrollments in the English language courses grew from 10 to 134 in a 3 year period. The institution's geographical service area is worldwide with a primary focus in Asia and the Pacific. This target area applies to both on-campus and eLearning programs. The goal of international online students is preparation for on-campus study.

Institution PTP has 15,000 students, of which approximately 600 are international. A total of 6,852 are enrolled in online programs including 900 international students; 1,600 on-campus students are enrolled in an online course. The administrator responsible for the program indicated that online enrollments from outside the United States are projected to reach 20,000 by 2017. The institution began with an enrollment of 49 students in 2010.

Similar to Institution SRL, the target region for Institution PTP's online program is worldwide with a focus in Mexico and South America as well as Africa, Russia, the Ukraine, and Canada. International online students are primarily seeking to complete online degrees to further their employability rather than coming to campus. One difference between the institutions is that Institution SRL has a much more extensive on-campus international population although both universities are focused on global eLearning outreach.

4 RESULTS

Case study methodology relies on combining the data sources to understand the case as a whole and the contributing factors (Baxter & Jack, 2008). As such, the data was analyzed and converged and themes identified related to the conceptual framework consisting of program components and their relation to the issues evident in the literature—access, affordability, and learner support with an emphasis on English language learning. Each artifact and information source was reviewed including the learner, teacher, and administrator interview data to determine the viability of practices and curriculum design to understand how the components contributed to effective eLearning. The researcher examined the information based on the learning theories introduced in the literature review and the issues of global higher education. A discussion of the resulting themes follows. Supporting quotations from students may contain grammatical errors due to their emerging English language proficiency.

4.1 Access

Access consists of admission, academic foundations, and affordability. Admission requirements for the online programs are similar at both institutions. Neither requires high school completion or specific marks. However, Institution SRL requires intermediate level English language proficiency measured by a standardized English language test. Admission to Institution PTP involves a proficiency test but students with any level of English can enroll.

At both institutions, admission to on-campus study involves specific academic and English language requirements such as high school marks and standardized college readiness and English language test scores. Grades in online English language courses are considered in the admission process for on-campus study at Institution SRL and these courses count toward a degree. At Institution PTP, completion of Academic Start, consisting of English, math, and student development courses (learning strategies and life skills), with a B average is required for admission to online degrees. Students wanting to enroll on-campus must meet regular admission criteria.

In terms of academic foundations, the program at Institution SRL prepares students for on-campus study and reduces their time to a degree through online English language coursework. It offers intermediate level courses in reading, writing, listening, and speaking. A limited number of online introductory university courses, including a student development course, are available post-completion of English language requirements and a few associate degrees are in development.

Academic Start at Institution PTP provides students with the basic skills to complete an online degree. The English language component is an advanced level integrated skills course, which emphasizes writing. A math course helps students prepare for college-level math requirements. A student development course introduces the institution's learning model and focuses on general life and study skills. A 1-credit hour orientation course is taken prior to the first online course.

The curriculum in these preparatory programs aims to increase access to further education through the acquisition of academic English language skills, and in the case of Institution PTP, with basic life and math skills. The long-term goal is to improve learners' employment opportunities and potential for societal contributions.

Cost has been adjusted based on regional economies. Institution SRL's tuition ranges from \$25-\$110 per credit hour depending on geographical region or country whereas the scale at Institution PTP is from \$20-\$65 per credit. The outreach of the latter institution extends to learners in developed countries who could benefit from open admission, low-cost degree opportunities. This institution also differs from Institution SRL in that it offers a considerable number and types of online degrees. Students can earn a bachelor's degree for just under \$8,000 U.S. in the United States, and as low as \$2,400 U.S. for international students. The focus of the online offerings at Institution SRL is primarily English language coursework with a limited number of certificate and associate degrees in development.

Both institutions desire to lower barriers to education by offering open access, low-cost, high quality online learning. The administrator at Institution PTP indicated that the goal is to have "high quality courses so that students will like them and want to continue taking them." Institution SRL has a primary emphasis on English language acquisition for students wanting to be admitted to on-campus study whereas Institution PTP offers online degrees at the certificate, associate, and bachelor levels and the broader Academic Start program with some English language coursework.

4.2 Learner Support

Concern with student success is evident. The learning support theme focuses on completion, online support, and learning models. Completion is encouraged through a year-round academic calendar, emphasis on utilization of summer terms, and online learning. The goal is to complete a bachelor's degree in 3 years as opposed to the 4 years normally required in the United States. Both institutions offer online learning support in the form of academic advising; peer tutoring; email, telephone, and live chat technology help; optional English language and technology tutorials; and library access.

More innovative support is evident in the institutions' learning models which offer opportunity for linguistic and learning skill development. At Institution SRL, course design is based on the theories of self-regulated learning, language acquisition, and transactional distance. Courses and instructors facilitate learner responsibility for managing the factors that affect their learning while developing English language proficiency. The administrator at Institution SRL describes SRL as the “backbone” of the courses. Students set goals, learn and apply strategies, analyze performance, and modify goals. They submit self-evaluative weekly learning journals and midterm and final performance reports. Various assessments of language skills are administered throughout each course.

The reflective journals indicate learner views regarding SRL. Related to methods of learning, one student commented: “I have become very good at guessing the meaning of new words in a sentence or paragraph.” The following indicates the use of two SRL dimensions – social environment and methods: “I have learned to further improve my study site. . . . I put a whiteboard in my room. I write on my whiteboard new verbs each week.” The midterm and end-of-semester evaluations provide further insight and examples of how SRL benefited learners: “One of the surveys I like the most is where we have to identify our values and goals. Seeing this I feel a sense of motive.”

Teachers are introduced to SRL in a training course which involves setting goals to facilitate learners' SRL behaviors. Teacher comments illustrated support for the approach:

> Goal setting and planning is something that I enjoy on a personal basis so I think those areas are something I can help my students with, and the way I want to do this is to identify an upcoming self-regulated activity and post an announcement concerning it.

Another indicated:

> The MYL assignments are very useful; for example, the one about developing positive self-talk. I have learned that aside from the ideas listed in the assignment, keeping gratitude and/or positive thoughts journal can make a huge difference in learning.

The training also familiarizes teachers with the institution and the on-campus English language program, technology, planning and preparing for class, sources of help, methods of learner feedback, tracking student progress, and creating an online community. The following comments indicate teacher response to the training: “I really want to prepare and make my course more navigable. I have a long list of goals for improving the flow of things.” “I am looking forward to reaping the rewards of implementing these great strategies.”

Teachers in the training course completed an end-of-unit reflection and goal-setting assignment and participated in a discussion board. The latter supported community-building. Both revealed some challenges with online teaching: “Honestly speaking I think this last week has been a little confusing for the majority of us. This discussion was helpful in seeing what other teachers have been dealing with and reading the answers to their questions.”

Technology issues tended to get more attention in the discussion forum than pedagogical issues as did specific questions about courses: “The assignments didn't roll over to my calendar and I've been trying to fix it.” “I'm barely keeping my head above water. My [section] doesn't have a tutor, and I don't know who to contact to find out what is being done about this.” The discussion board provided insight into teacher experiences and issues.

Institution PTP has a 3-stage course design model: prepare, teach, ponder/prove. Students prepare by studying assigned materials, completing homework, and participating in groups. In the second stage, they teach each other by sharing their understanding of course content in instructor-facilitated discussion forums and on-site gatherings facilitated by volunteer senior couples and led by students (which supports the “teach” aspect of the learning model). The final stage involves review, reflection, and application. Students take quizzes and submit self-assessments.

The self-assessments consist of five or six prompts from which students choose such as what is most difficult, what they like best, how the course differs from how they have learned English previously, what they think would help them do better, the most helpful thing they learned that week, a goal they would like to pursue, what they learned from their classmates, their strengths and weaknesses in English, and future plans for using English. The prompts are either connected to the lessons (e.g., how writing good letters might be useful to them) or are general in nature (e.g., the most important thing they learned). At the end of the course, they ponder their experience and next steps in terms of education or employment.

The reports encourage student responsibility for learning and the identification of specific steps for improvement. One student wrote: “I learned that use of transition words help us create coherence in our paragraph and how to correctly use determiners in a sentence. My goal for the next two weeks is to use this knowledge in the essays that I have to do.” Another commented on her reasons for learning: “I need to improve and increase every day my skills in this language, and I am doing it, for my kids for a better life for them. Also, I can help better others with my talents and my skills.” Specific to the model, one student wrote: “This learning model provide me a mental graph of how should I develop my study method to fit in the model."

Teachers at Institution PTP certify as online teachers prior to teaching their first course. Similar to the training at Institution SRL, the certification familiarizes teachers with the learning model, institution, and purpose and design of the online courses. It helps them develop online facilitation and teaching skills. Teachers interact with each other in discussion forums throughout the training. The course parallels the learning model that students experience—prepare, teach, and ponder.

Each semester, teachers participate in a discussion forum facilitated by a lead instructor who posts topics. Examples include motivating students, dealing with plagiarism, managing difficult students, implementing effective discussion boards, and providing feedback. Regarding the latter, one instructor commented: "I feel like this semester has been very productive for me. I'm getting better at knowing how to fulfill my role as an instructor, and I'm learning what it is that the students want and need from me. I think one of the things that I've learned is how to give better feedback."

In addition, instructors can post questions. For example, one instructor inquired about how to divide students into small groups for the discussion forum and the advantages of this. Since both new and experienced teachers participate, the forum is an example of instructors teaching each other as the students do in their courses. Themes from the forums tended to focus on pedagogy rather than technical issues, in contrast to Institution SRL. Colleague support is evident in the following: "Teaching online does take some getting used to, but you seem to be transitioning well. For me, it took a few semesters to really feel comfortable with it."

Each week, teachers complete a reflection report in which they comment on the amount of time they spent on the course, their currency with grading assignments, how they helped struggling students, and items of concern for their course lead.

The course design and curriculum supports program purpose at both institutions. Provision is made for needed English language preparation, and at Institution PTP, for other basic skills. Learning models have been developed to address student need for effective study habits and strategies and increase autonomy with the aim of course completion and future academic success. Credentialed instructors, both full and part-time, are trained for online teaching and in the learning models. They also receive on-going support. Thus, high quality instructors, student support mechanisms, and sound teaching and learning approaches are evident.

4.3 Linguistic Considerations

Courses in both programs include the strands of a well-balanced English language course (Nation, 2001). Institution SRL provides comprehensive offerings with skill-based courses in reading, writing, listening, and speaking. Input is provided through readings and listening (textbook excerpts, videos, lectures, scripted and narrated PowerPoint slides). Output occurs through writing assignments, video posts, and weekly live interactive peer tutoring. The latter is structured with specific discussion topics although learners can ask for help with other issues. Instructors may have live video conferences with students to discuss progress and SRL goals. Deliberate instruction in grammar, vocabulary, reading skills, and writing techniques is present. Fluency is developed through timed reading exercises, learner journal reflections, discussion board postings, and other activities.

Thus, courses consist of a linguistic input; opportunities for output; deliberate study of grammar, vocabulary, and pronunciation; and fluency building. The assignments and instruction provide structure, and teacher facilitation, which is further developed through training, provides dialogue (Moore, 2013). Student discussion forums and videos are also sources of dialogue and provide output opportunities for rule-testing and real-life meaning negotiation (Long, 1996).

The Institution PTP English language course focuses primarily on academic writing—organization, grammar, vocabulary, and rhetorical patterns. Input is provided primarily through reading and some video while output involves writing, discussion and video posts to other students, and twice weekly live interactive appointments with a peer tutor. Students meet weekly with other students in their geographical area, which provides further language interaction.

As with Institution SRL, these course components fulfill the requirements for language acquisition as well as providing differing amounts of structure and dialogue to promote autonomy and individual responsibility for success. Autonomy is particularly evident in the *teach each other* aspect of the learning model, operationalized in the discussion forums and weekly gatherings. Students are provided with a lesson plan for the gatherings, but must use their English skills to communicate and know the material well enough to share it with their peers, thus both language acquisition and autonomy are supported. An additional advantage is increased confidence in using the language as evident from a student's learning report:

> I realize I have the capacity to learn and understand more about English language. I'm feeling more comfortable with my drafting and grammar now. I can share my feelings and thoughts more easily and I think others can understand me more and better than before this semester.

5 DISCUSSION

The purpose for the two programs is similar and addresses global education needs. Both lower barriers and provide access in terms of admission and cost although Institution PTP has a broader and more fully developed online presence, allowing students to complete degrees. Institution SRL focuses primarily on English language acquisition with the intention of students transferring to campus. The following discussion reviews the issues in the literature regarding global learning and the extent to which the institutions address them.

Linguistic, educational, cultural, and technological needs (Andrade, 2013) are accounted for. The institutions seek to develop learners' academic English skills to make future study accessible. The curriculum encompasses the necessary strands of a well-balanced language course. Institution SRL provides extensive English language coursework. Given its international enrollment, this is an area of expertise and ensures the institution's academic integrity. Institution PTP has only one English language course but the curriculum targets needed academic English skills.

Regarding academic preparation, Institution PTP offers students the basic skills support typically needed by those who are academically underprepared (e.g., English, math, student development) while Institution SRL offers, but does not require, selected academic courses, with additional courses and degrees in development.

The institutions have well-developed learning models that account for cultural adjustment by ensuring that students have the self-sufficiency to be active learners rather than teacher-dependent. They guide students in examining goals, evaluating performance, applying new methods, seeking help, and developing self-regulation in support of distance learning and educational theories (Moore, 2013; Zimmerman, 1994). Learner and teacher feedback attests to positive experiences with the models.

Tutorials and live technological support is provided. Socialization, and language interaction, occurs through face-to-face connections with peer mentors who assist students with course content, answer logistical questions, and direct students to other sources of help. Thus, technological assistance, socialization, peer support, and English language practice are provided.

6 CONCLUSIONS

Future exploration should determine student success in continued study such as performance in language intensive courses and degree completion would help determine the effectiveness of the curriculum and learning models. Comparisons with on-campus students, including those who have met higher admissions standards, would also provide insights.

Both institutions fulfill a need—increasing accessibility to higher education on a global level. Students can study anywhere, anytime at a reduced cost. Obstacles to obtaining a degree are addressed—insufficient finances, busy schedules, rigorous admission standards, and lack of learner confidence. Increasing enrollments in eLearning courses attest to the need for the programs, and are evidence of positive word-of-mouth communication among learners.

The institutions are at different points in their development and the comprehensiveness of their offerings; however, both provide global learners with the opportunity to acquire English language skills in online learning environments to build a foundation to further study. The institutions recognize that distance education increases access, allowing more individuals to reach their potential.

This study contributes to the field of global eLearning through an intrinsic case study of two institutions that have implemented innovative global eLearning programs. The programs address the need to provide "sufficient publicly funded support to expand higher education" (Hanna, 2013, p. 684), which is "a requirement for individual, community, economic, and collective well-being (Hanna, 2013, p. 684). Greater understanding of the models, the goal of this study, can lead to innovative practices at other institutions.

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Instructor Support in Collaborative Multiplayer Serious Games for Learning

Game Mastering in the Serious Game 'Woodment'

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Abstract: In collaborative digital learning scenarios with small groups (3-6 users), the role of the instructor is vital as he/she is responsible for preparation of the setting, observation, coaching, moderation and adaptation. Currently, in multiplayer Serious Games, the role of the instructor is only insufficiently considered. Only very few approaches for integrating or supporting instructors in collaborative multiplayer Serious Games exist today, to the best of our knowledge. In this paper, we propose a concept for integration and support of instructors in team-based collaborative 3D multiplayer Serious Games. Our approach is based on Game Mastering principles known from roleplay games. It combines those principles with concepts for collaborative learning scenarios. We applied our concept to the existing 3D multiplayer Serious Game *Woodment* and tested it in a vocational school with 26 players in four groups (age: *m= 19.12; sd= 2.03*). Results indicate that an instructor using our Game Master framework to moderate and adapt the game at runtime can have a positive effect on both the players' learning success and perceived user experience. Moreover, a positive effect on players' gaming behavior can be observed.

1 MOTIVATION

Although many promising examples of Serious Games for learning are existing today, most of those are single player games.This is true even for social Serious Games (Konert et al., 2012) which are usually played alone despite asynchronous interaction with other players/friends. We believe that multiplayer Serious games can be a promising opportunity to combine the advantages of Serious Games with the concepts of collaborative learning, especially Computer-supported Collaborative Learning (CSCL). However, in (computer-supported) collaborative learning scenarios, the role of the instructor is vital. (Hämäläinen et al., 2006) argue that "*Computer-supported Collaborative Learning (CSCL) must provide instructional support*". The instructor is responsible for various tasks in and around the learning process. According to (Haake et al., 2004), page 30, those are, among others, analysis, monitoring, moderation, guidance, coaching, and intervention. However, to the best of our knowledge there are only very few approaches to support an instructor in digital game-based collaborative learning scenarios.

Our approach uses concepts from Game Mastering (in pen&paper roleplay games), collaborative learning, and collaborative gaming. In (Wendel et al., 2012a), as a first step, we proposed a model-based approach for a Game Master concept in 3D Multiplayer Serious Games. The paper focused on the interface between the game and the Game Master frontend as well as on a group model consisting of a player model, a learner model, and an interaction model. The main contribution of this paper is an extension of our model by proposing methods and concepts for providing a Game Master with the ability to analyze, monitor, coach, intervene, and adapt at runtime from inside the game. Therefore, we will describe methods for getting required information from the game to perform those tasks as well as for providing adequate methods of adaptation of the game. We implemented our extended concept as an extension to the existing collaborative multiplayer Serious Game *Woodment* (Wendel et al., 2010) and performed a user-centered evaluation at a vocational school in Germany. Our hypothesis is that an instructor using our approach can positively influence both game experience and learning outcome of players in an immersive way. The study was conducted at a vocational school in Germany with 26 students (age: *m= 19.12; sd= 2.03*).

Results show that an instructor using our Game Master frontend to moderate and adapt the gaming process at runtime can have a positive effect on both the learning success and the perceived user experience of the players. Moreover, different effects on the gaming behavior of players can be observed like a more focused play style and a more coordinated teamwork.

2 RELATED WORK

The concept of Computer-supported Collaborative learning (CSCL) is being used in various learning scenarios ranging from learning at school, university learning, to training scenarios in corporate environment (Shell et al., 2005), (Stahl et al., 2006), (Onrubia and Engel, 2009), and (Larusson and Alterman, 2009). As stated by (Kearsley, 2000) or (Chiriac and Granström, 2012), the instructor's role is vital in collaborative learning scenarios. Instructors have various important tasks during collaborative learning sessions. (Mutwarasibo, 2013) states that "*the instructor's role in student group work is that of a guide or facilitator*". A more detailed description of instructor tasks in collaborative learning scenarios, especially in CSCL scenarios is given in (Haake et al., 2004), page 30. There, the tasks of an instructor are described as: analysis, monitoring, moderation, guidance, coaching, and intervention.

Grand challenges of multiplayer Serious Games research are: multiplayer Serious Game design, interaction and communication on game-based collaborative learning scenarios, and the role of the instructor as well as instructor support. (Hämäläinen et al., 2006) describe a concept for designing collaboration in a 3D virtual game environment. The role of the instructor concerning real-time orchestration in a 3D game is discussed in (Hämäläinen and Oksanen, 2012). Design guidelines for incorporation of features of collaborative learning in video games are presented by (Zea et al., 2009). (Wendel et al., 2010) describe the design of a collaborative multiplayer Serious Game for collaborative learning. The work presented here is based on this game.

The concept of Game Mastering as it will be used in this paper, is derived from pen&paper roleplay games. In such games, the Game Master (GM) is responsible for telling a suspenseful and interesting story to a group of players which are active parts in that story. Thus, they are able to actively influence that story, oftentimes against the GM's plan. The GM's task is to keep the story meaningful while at the same time allowing a maximum of freedom for the players without giving them the feeling that their actions are futile. Thus, it is the GM's task to unite those goals (well considered story vs. player freedom). This problem is often referred to as the Narrative Paradox (Louchart and Aylett, 2003). Therefore, the GM needs to be able to observe the game in the context of the whole story and be able to adapt his/her plan ad-hoc according to the needs and preferences of the players. These requirements are similar to those of an instructor in a (game-based) collaborative learning scenario. First concepts to formalize the work of a Game Master in order to transfer the Game Master concept to digital games have been proposed by (Tychsen et al., 2005) and (Tychsen, 2008).

Various concepts for modeling player behavior and preferences have been proposed up to today. The most prominent player model is Bartle's model for roleplay types (Bartle, 1996). A more generic model has been proposed by (Houlette, 2004). A comprehensive overview over player models is provided in (Smith et al., 2011). They provide a taxonomy of player modeling. In terms of learner modeling, the concept of (Kolb and Kolb, 2005) is one of the most prominent concepts. However, for the scope of this work, we focus on modeling the learning progress of learners. Therefore, we need to model what a player/learner has already learned. It is also desirable to be able to make suggestions for the next learning unit based on already learned content. Therefore, a hierarchical approach to modeling learner skills seems suitable like proposed by (Korossy, 1999).

3 OUR APPROACH

The approach presented in this paper is based on our concept for Game Mastering as described in (Wendel et al., 2012a). There we propose a component-based model for describing a 3D multiplayer Serious Game. Our concept defines a 'group model' to model players/learners. The group model is composed of a player model, a learner model, and an interaction model. In this paper, we want to extend that model about a client sided interface declaring how information from a game can be extracted to be presented to an instructor in a useful manner. Furthermore, the extended model defines an interface for accessing relevant game entities in order to be able to adapt the game at runtime.

3.1 Architecture

The architecture of our framework (see Figure 1) contains two main elements: One is the 3D game itself, the other one is the Game Master frontend. Via the

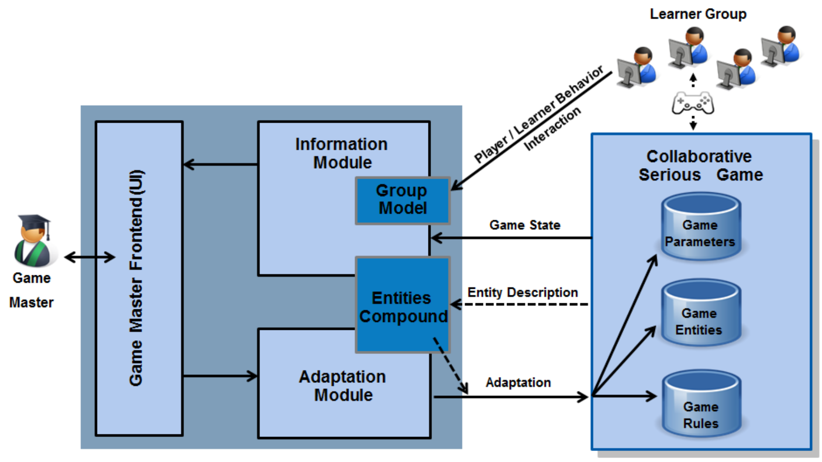

Figure 1: GM Framework Architecture

defined interface (between game and frontend), the Game Master frontend can access relevant data from the game and on the other hand adapt game rules or entities. The Game Master can use the GM frontend to receive necessary information and to influence the game according to his/her professional knowledge in order to optimize learning success, gaming experience, and collaboration. The interface is split into four sub-components: *Entities Compound*, *Group Model*, *Information Model*, and *Adaptation Model*. The components will be explained in more detail below.

3.2 Entities Compound

The *Entities Compound* defines all relevant game entities. According to (Wendel et al., 2012a), 3rd person 3D games consist of three main parts: Game World, Players, and Interaction. The *Entities Compound* describes the former two of those. It defines all relevant game entities. Relevant entities are all those game entities which's state influences the state of the game. Those are of course the player entities. Additionally, all 3D assets which have a purpose beyond setting the scene, i.e. background images, static 3D objects, and terrain. Generally, those are all game entities a player can interact with in any way. It is task of the game designer to define which game entities are relevant and which ones have only a decoration purpose. A game entity exists of a description, describing the function of the entity in the game, and a list of parameters. For each parameter the game designer needs to define if it is only informational or if it can be changed. Additionally, a parameter description needs to be provided, explaining the parameter's function for the entity.

3.3 Group Model

The *Group Model* contains the state of the group of learners. It is described in detail in (Wendel et al., 2012a). It provides information about player behavior and preferences in play style (player model). Furthermore, it describes the learning progress for each player. Finally, it contains information about interaction and communication between players.

The *Player Model* describes preferences in gaming behavior for a player, e.g. if a player prefers action, socializing with other players, or wants to experience every aspect of a game, i.e. find every hidden piece of it. The most common and best fit player model for those RPG-similar 3D multiplayer games is the player model of Bartle (Bartle, 1996). It classifies players along two axes (players - world, acting - interacting) resulting in the four stereotypical player types: killer (player, acting), achiever (world, acting), socializer (player, interacting), and explorer (world, interacting). Again, the game designer(s) need to specify which action and decision a player can take during the game relates to which player type. In our model, this is done by assigning player model modification values to relevant player actions.

The purpose of the *Learner Model* is to give the instructor a structured insight into the learning progress of players. Following the hierarchical model of Korossy (Korossy, 1999), the game designers/subject matter experts define a set of skill which will should be learned throughout the game. Those are ordered in a hierarchical structure indicating dependencies between skills. A skill depends on another skill if that other skill should be learned before this skill is looked at.

The *Interaction Model* is meant to provide the instructor with information about interaction between players. This contains any means of communication. Usually, this includes a chat protocol. A more detailed look into communication between players contains statistics about the frequency of communications between players. Apart from communication, interactions are taken into account. Therefore, the game designer needs to define which actions in a game taken by a player are an interaction with another player. This is similar to the actions defined for the player model.

3.4 Information Module

Apart from collected data like the group model, it is useful for the instructor to be able to directly observe the gaming progress (Haake et al., 2004) in order to be able to extract information about the collaborative learning process. Moreover, it might be useful for recognition of problems players might have at certain points in the game. Therefore, it seems useful for the GM to be able to move freely in the game world, i.e. have a free camera perspective. Moreover, in order to be able to spectate what all players are doing at a certain point of time when players are split up, it is useful to provide a split-screen camera. Apart from this, the GM should be provided with the information of the group model. Finally, general game parameters as well as information about the state of game entities should be displayed.

3.5 Adaptation Module

The *Adaptation Module* is the part where the instructor can influence the game by *adapting game parameters*, *adapting parameters of an entity*, and *adapting a game rule*.

Therefore, it needs access to the basic game parameters as well as to the game entities. Thus, it is connected to the *Entities Compound*. In addition to that, it needs to access the rule base of the game. As game rules significantly influence a game on a very basic layer, the game designer needs to define which rules may be changed in which way. For example, it could be allowed to perform a certain action or not. In order to simplify this access, an abstraction interface will be put between the game rule base and the *Adaptation Module*. Changing game rules can be implemented through adapting a set of (boolean) parameters, provided game rules are designed carefully. Note that learning parameters, like difficulty of questions, etc., are capsuled in game parameters or parameters of (learning) entities. However, they should be displayed to the GM in a suitable way separating them from gaming parameters. Thus, via the adaptation module, the GM is able to manipulate relevant 3D objects, game rules (i.e. interaction rules, rules for collaboration, game actions), and difficulty in terms of gaming, or learning.

4 PROOF-OF-CONCEPT

4.1 Woodment

As a proof-of-concept, we implemented our approach as an extension to the existing Serious Game prototype *Woodment*. The game has been chosen because it has a rather high level of interaction and a trainer/teacher can freely define the learning content. It is possible to create, save, and reuse question sets of various content domains and even to mix them if so wished. *Woodment* is a 3D 3rd person multiplayer digital educational game for 6 players. The game has been developed by the authors and been enhanced during practical courses or theses. One enhancement of *Woodment* was performed as a part of a diploma thesis which focused on Game Mastering concepts and team leadership (Rodenberger, 2012). Some of the visualization concepts presented in this paper have been reimplemented from this work.

Woodment as well as the enhancements implemented as a proof-of-concept for the work presented here, was implemented using the Unity3d game engine. The game can be played both in browser (Unity browser plugin required) and as a standalone application (for PC and Mac), providing us with the necessary platform independence for evaluations on varying hardware in different vocational schools.

4.2 Game Entities

Question orbs contain questions which can be triggered when a player enters the orb. They provide a game relevant resource (food, workers, or ship tokens to sell wood) if the answer is correct. The Game Master can adjust their size and movement speed as well as the frequency each question orb type spawns with. Skill canisters can be picked up in order to be able to run faster, freeze an enemy player for a period of time, or to ignite the enemy base forcing the enemy team to spend time to extinguish the fire. The GM can adjust their spawning frequency. Workers gather resources provided that they have sufficient food. They cannot be accessed directly by the GM. The player base is the center of operations for a team. The GM can view it and see if it is currently burning, but not directly adjust that fact.

4.3 Group Model

We defined several player actions like 'Pickup Skill Canister', 'Trigger Question', 'Answer Question Correctly', 'Ask For Help', or 'Help Player With Question', which affect one or more of the player model items (*killer, achiever, socializer, explorer*).

Woodment contains an integrated editor enabling the instructor to create a custom set of questions. The set of questions as well as dependencies between questions are created by the instructor according to the learning content. Thus, it is possible to model the learning space according to the Competence-based Knowledge Space theory (Korossy, 1999). The actual learner modeling is done by modeling the learners' initial knowledge and monitoring the acquisition of knowledge during the gaming phase and updating the learners' knowledge state accordingly.

All player chat is directly visible to the GM. In addition, player chats are aggregated such that for each player it is known how often he/she communicated with each other player. This is presented to the GM graphically. In terms of interaction, the game records whenever a player asks for help or gives help for a question. Also, whenever a player freezes an opponent or de-freezes a fellow player, the interaction counter for the affected players increases. This is also presented graphically.

4.4 GM Observation Frontend

To satisfy the needs for observation of the gaming occurrence, we implemented a 'fly mode' for the GM, i.e. the GM can move freely within the game world. This includes a smooth zoom. Moreover, the GM can automatically follow each player by clicking the player's name. A split screen mode was not implemented as dividing the screen into 6 parts seemed to be too confusing. The group model is displayed in a special window providing overview over each player's player model, learner model, and interaction model. The GM can view game entities directly in the game world and see their parameters in the settings window.

4.5 GM Adaptation Frontend

The GM can adapt game entity parameters (if allowed) in the settings window. Moreover, the GM can directly adjust the most significant game parameters directly on the main screen. Those are the number of wood gathered, workers, ship tokens, food, or gold for each team. Further, the GM can adapt some visual options like sunlight, brightness or fog which indirectly influence the game (difficulty). Poor sight makes finding question orbs harder which increases the need for communication among team members.

5 EVALUATION

5.1 Hypothesis and Setup

Our Hypothesis is that an instructor is able to support and positively influence the collaborative learning process as well as the game experience of a gaming session, especially the game flow. A Game Master (GM) frontend is implemented, following the concept presented in this paper. Therefore it is hypothesized:

1. Comparing with a scenario without a GM, a GM increases the flow experience and user experience.
2. Comparing with a scenario without a GM, a GM increases the learning success.

Participants were playing one of two versions of *Woodment*. The treatment group was playing *Woodment* with support of a GM, while the control group was playing the standard version without the support of a GM. Both groups were playing *Woodment* for 40 minutes and answered a questionnaire after playing the game. The questionnaire was a modified version of the user experience questionnaire described in (Wendel et al., 2012b) and includes an overall user experience (UX) score, as well as seven UX sub-scales. The in-game answers to the content of the curriculum were logged, too, as well as all player and GM actions. For both groups (treatment and control group), two gaming sessions with 6(7)[1] players each were conducted. Players were from different classes of a vocational school in Germany. The study includes 26 participants, 18 male, 5 female and 3 not stated. Age $m = 19.12$ ($sd = 2.03$). To analyze the data an ANOVA between subjects was used. The present of the GM was used as independent variable and the overall scale, as well as the seven sub-scales were used as independent measurements.

5.2 Results

The GM version ($m=6.14$; $sd=1.44$) triggered more overall user experience ($F(1,23)=6.93$; $p=.015$) than the control group without a GM ($m=4.90$; $sd=0.89$). To detect which aspects of user experience are especially distinct in the GM version, the seven sub-scales were tested, too. The sub-scales Immersion ($F(1,23)=7.54$; $p=.012$), Flow ($F(1,23)= 11.50$;

[1] due to class sizes, in two groups we had 7 players, two students each played together on one computer

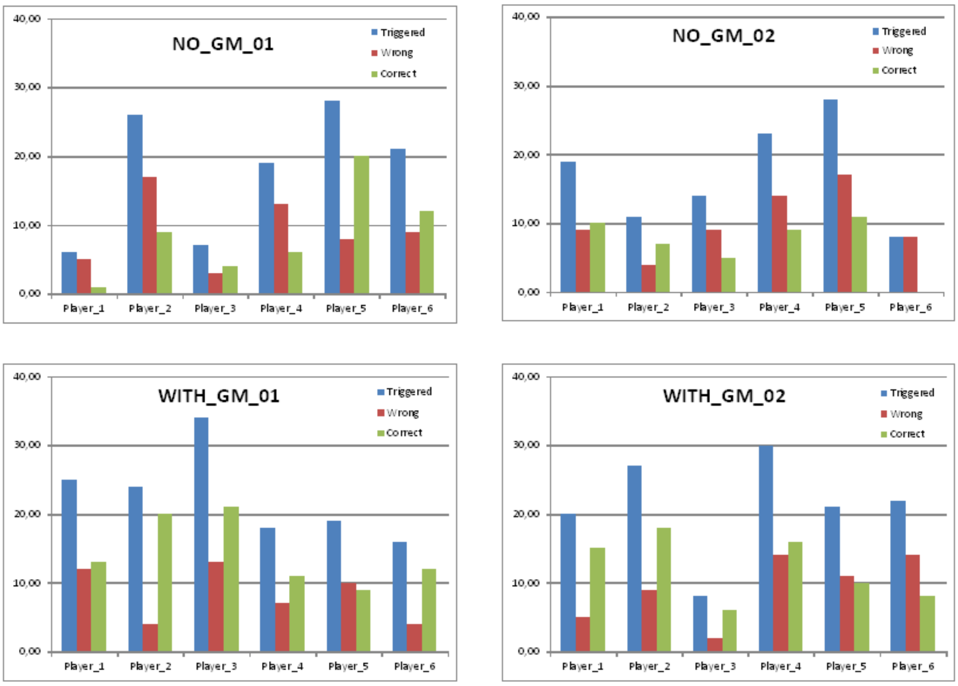

Figure 2: Questions answered by player

p=.003), and Arousal (F(1,23)= 4.25; p=.051) showed an effect in favor of the GM version.

During the gaming sessions, the game logged all relevant data. Logged data contains all GM and player actions, triggered questions and answers, chat data and all game variables logged in a one second interval. From the post-processed data we could see the progress of resources (wheat, fish, workers, idle workers, lumber, gold) for each team over time[2]. Moreover, we aggregated the data for the questions answered (see Figure 2) by the players and the player models (see Figure 3).

Figure 2 shows the number of questions triggered, and answered correctly or wrong for each player. More questions (*F(1,22)=6.77; p=.016*) have been solved correctly in versions with a GM (*m=13.25; sd=4.81*) than in versions without a GM (*m=7.83; sd=5.37*). Also, the percentage of correctly solved questions is higher (*F(1,22)=7.53; p=.012*) in versions with a GM (*m=61.21; sd=14.24*) than in versions without a GM (*m=41.58; sd=20.29*). As an indicator for the overall success of a team, we looked at the gold they were able to achieve. Without a GM, the teams got 2/2 (red/blue) and 2/3 (red/blue) gold (9 gold total among all four teams). The teams with a GM got 3/3 (red/blue) and 2/4 (red/blue) gold (12 gold total).

[2]For reasons of clarity and available space, we cannot include all of those plots in this paper. However, they are available from the authors upon request.

5.3 Discussion

Results show that both UX questions and the percentage of correctly answered questions are significantly larger in the game sessions where the GM was present and used the GM frontend. Thus, we can accept both hypotheses.

Comparing the player models, it comes to the fore in the sessions where a GM was present, players were generally more active. The values for explorer (232/254 with GM, 158/152 without GM) show that players tend to move more when a GM is present. This indicates that players were more actively searching for question orbs or supporting fellow players (e.g. de-freezing). However, as we cannot track the purpose of a movement, it needs to be clarified that higher explorer values can also mean that the respective player might just be moving around for other reasons. Achiever values (350/333 with GM, 264/238 without GM) indicate that players play more competitive when a GM is present. Collaboration values do not differ greatly (84/77 with GM, 50/84 without GM). Killers are also more active (100/134 with GM, 73/93 without GM) when the GM was present. Overall the activity (total number of actions performed)

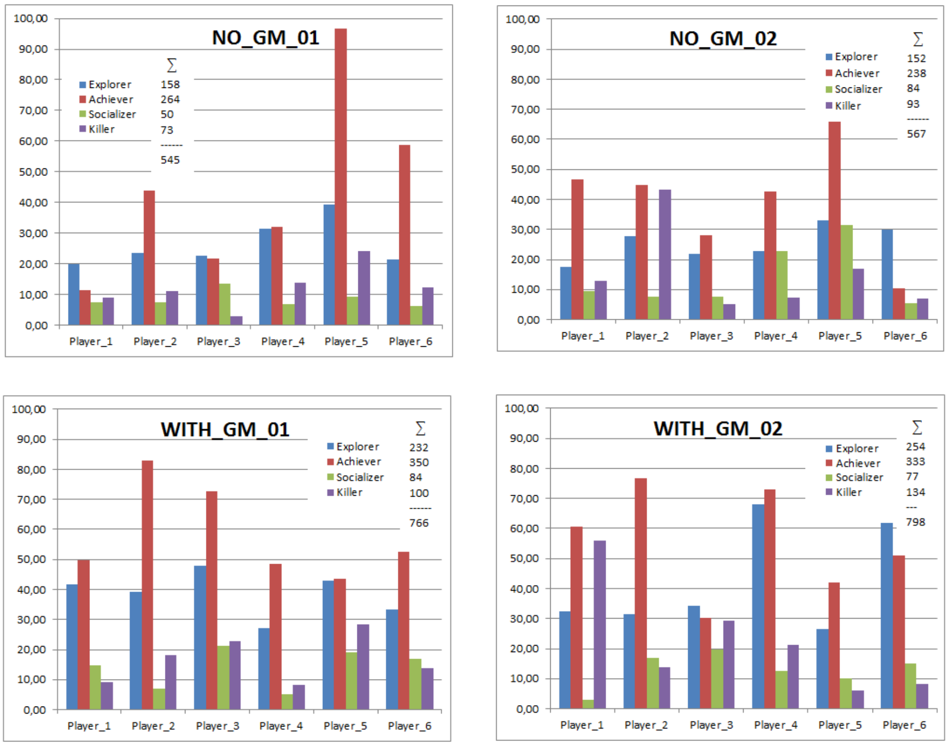

Figure 3: Player Model

was higher in those games where the GM was present (766/798 with GM, 545/567 without GM).

From the observations described above, we conclude that the GMs were able to make students focus on their tasks by reducing disturbing behavior and by recognizing problems in teams. Moreover, it seems that GMs were able to recognize problems/errors at answering questions and that they were able to provide useful help, thus increasing both the average number of questions triggered, and the amount of correctly answered questions. This indicates that the GM was able to fulfill his/her traditional tasks like observation or coaching, and help players learn better while improving UX.

5.4 Limitations

The findings of this paper are limited by the following constraints. The game sessions have been conducted with only a small number (26) of participants of which 18 ware male. Although the students enthusiasm towards playing the game and their motivation during the gaming time was seen as very positive by their teachers, it needs to be considered that this might at least partially result from the fact that playing a game was just a more fun alternative to regular class sessions. Our concept was only evaluated using one implementation for one game (*Woodment*), thus a general validity for all types of collaborative multiplayer Serious Games can not be derived.

6 CONCLUSION

In this paper we proposed a model for assisting an instructor in orchestrating a collaborative multiplayer Serious Game. Our concept is an extension to our prior work on a framework for Game Mastering in collaborative multiplayer Serious Games. It defines an interface for game developers and subject matter experts, which can use it to define relevant game entities, game parameters, or learning content. We further provide a concept for a group model based on player modeling, learner modeling and interaction modeling. Our concept addresses a suitable way of presenting relevant information to the instructor (GM) and meaningful ways of adapting the game state and game rules via the interface. We implemented our concept as an extension of the collaborative multiplayer Serious Game *Woodment* and conducted a user-centered evaluation with 26 users. Our hypothesis was that an instructor is able to use a frontend implemented according to our model in order to perform vital instructor tasks in collaborative learning scenarios and subsequently be able to improve player performance in terms of game experience and learning success. Our results indicate that our hypothesis can be accepted with some limitations. Both UX and learning performance are significantly higher in the gaming sessions where a Game Master was using the GM frontend implemented according to our concept compared to those sessions where no GM was intervening.

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Observational Research Social Network
Interaction and Security

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Abstract: Quality in education depend heavily on the teachers' professional development, as a mean for pedagogical methodologies and practice improvement. In this sense, learning is enhanced by sharing and working in a community of practice, a learning organization that generate knowledge and allow members to innovate. In this context, children observation is fundamental, allowing a sound basis for reflection and action around learning experiences and teaching environments. Specific guidelines and programs, such as the EEL/DQP, can help reducing the inherent subjectivity, providing a common base for teachers and the preschool education community. In this paper we propose an online, web based community to improve the observation process as well as the communication between researchers. The social relations are identified and the security issues are discussed.

1 INTRODUCTION

The literature about teachers' professional development shows that communities of practice constitute centers for professional growth (Sheridan et al., 2009; Evans et al., 2006). In this sense, communities of practice are groups of people who gather from common professional interests and a desire to improve their practice, sharing their knowledge, ideas and observations. A community of practice can be understood as a social system for learning because, like other social systems, provide: i) a structure where they develop complex and dynamic relationships; ii) ongoing negotiations between members; iii) shared meanings and cultural identity (Wenger, 2010).

In this perspective, communities of practice can constitute itself as an opportunity for learning about what really matters, about epistemology, ontology and methodology that can sustain the praxis. Communities of practice are conceived as learning organizations which investigate their situation and their relationships and generate praxeological knowledge that allows teachers to innovate.

The Effective Early Learning (EEL) Project (Bertram and Pascal, 2004), known in Portugal under the designation *Desenvolvendo Qualidade em Parceria* – DQP (Bertram and Pascal, 2009) propose the creation of communities that develop a collaborative action, focused on shared purposes and in a sustained process of pedagogical mediation by an external supervisor. This intends to improve the quality of early childhood education contexts, through an active involvement of participants. It is a monitoring process that uses several observations tools requiring that professionals build knowledge and skills about the underlying processes that allow them to reflect with the peers about their action.

Observations in the EEL/DQP are used to assess children physical, emotional, social, and intellectual development, focusing on specific areas, such as social interaction, learning experiences, space management and creations, and others. They can also help to better understand how different areas of development are interrelated, as well as helping recognizing what behaviors are typical of various age groups. In turn, this understanding will help the teacher to improve as a person and as a professional.

Each observation process depends heavily on the sensibility and experience of the teacher. It is very difficult to get consistent results if the observers diverge in the way they interpret the setting. Although natural and inherent to the process, it is important to minimize this subjectivity. In order to do so, the observations are performed simultaneously by more than one teacher in a democratic way. The external supervisor also has a thorough perspective on the whole project and may participate in some or all observations. The bottom line is that to be able to get meaningful information, the communication between all the teachers and researchers is fundamental, as a way to foster reasoning and action building.

In this paper we propose the design and development of an online, web-based, regulated community, providing:

- A central and secure repository of observation data, results and annotations;
- A computer mediated social network.

This service allows each teacher to manage the observation process, sharing information with authorized colleagues and improving their experience and knowledge.

2 EVALUATION PROCESS IN EEL/DQP

The evaluation of quality of early learning in the scope of EEL/DQP requires obtaining a considerable amount of data through several techniques, including detailed observations of children and adults, interviewing parents, practitioners and children, documentary analysis and others. This complex and somewhat subjective process requires well-trained teachers and researchers. In particular, the EEL/DQP initiative defines a four phase/thirteen steps procedure (Figure 1).

Data is gathered and systematically organized in research portfolios, that will be used in a cyclic process of thinking-do-thinking to research and create change (Mesquita-Pires, 2012). This process is enhanced by the utilization of observation techniques which measure the effectiveness of the learning and teaching processes, such as the Child Tracking Observation Schedule, to gain a snapshot of the childs day and providing information of learning experiences (Bertram and Pascal, 2006), the Child Involvement Scale, an observation technique which measures the level of a childs involvement in an activity, the Adult Engagement Scale, to evaluate the interaction between the practitioner and the child (Laevers, 1994).

The application of the procedure has a broad set of difficulties and challenges. Initially, it is necessary that the research group learn about participatory pedagogies as theoretical foundations about EEL research techniques and the practicalities of their use. The application of interviews come soon after, which lead the participants to reflect on the ethical issues involving its use. Learning to observe is another challenge, because the signs are not always evident and

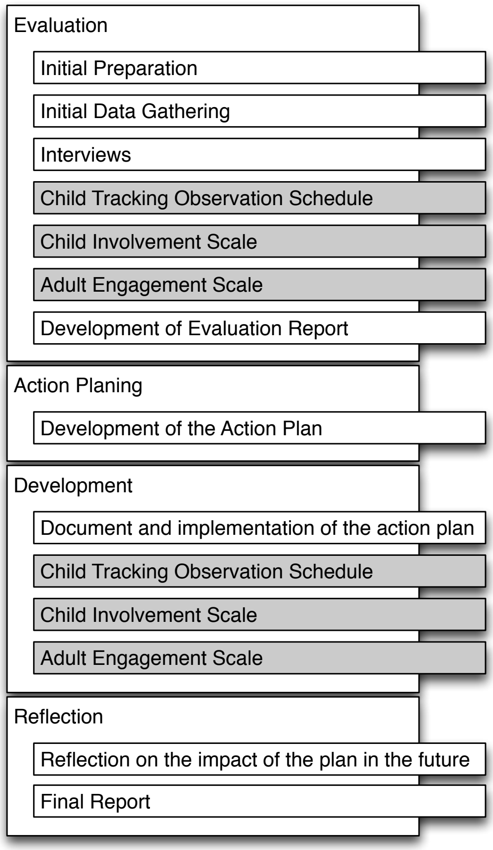

Figure 1: EEL/DQP phases and steps.

observers must be well trained to identify them. Besides, the observation process should be systematic requiring that kindergarten teachers find time in their daily routine to observe the children and understand how they are learning.

2.1 EEL/DQP Procedure

The EEL/DQP overall procedure follows the four phases described above. It starts by an initial orientation of the work to be performed, in which all the process is prepared and all the participants informed in detail. Initial data gathering follows, where the institution is characterized, including the interior and exterior spaces, its education philosophy, the different learning activities, and others.

The third step includes performing interviews to the dean, staff (about 50 %), children (20%), and parents (20%). It is very important that all the stakeholders are well informed and understand the process. The teacher records the interviews and take notes of key phrases, to support the written report. In the end, access to interview transcripts must be given to participants.

The fourth step requires an observation process, using the Child Tracking Observation Schedule, with the main purpose of understanding the child's daily routine. This technique gives information about the learning experiences, the level of choice, his involvement, the group organization and interaction with adults.

The Child Involvement Scale seeks to measure not only the learning outcomes but also the underlying processes. Essentially, it gathers information about the participation in activities and projects, thus giving indicators of concentration and motivation as well as of satisfaction (Laevers, 2005). When lacking, chances are that the children development will stagnate, and all the actors in the education process should do everything in order to create an environment in which children can engage in a wide variety of activities. The details are registered in a specific form.

The Adult Engagement Scale evaluates the interaction between the practitioner and the child (Laevers, 1994). It targets the effectiveness of the teaching-learning process through observation of adult-child interaction. The quality of the adult's intervention is a critical factor for the child's knowledge building. Up to a maximum of 5 adults should be observed, paying special attention to the sensibility, stimulation and autonomy categories.

2.2 Ethical Behavior

Ethical behavior is fundamental in the whole process, since it tackles professional behavior, privacy, and confidentiality concerns (always keep in mind that the observer is representing his school as well as himself). Children, parents and professionals should be treated with courtesy, always respecting the privacy rights of children and family.

All the participants in the project, including children, should be informed about all the details of the project and their role in the whole process, giving their consent. This will ensure that all of them are comfortable and willingly, contributing to better results.

During observations, teachers may gather sensitive information, such as details about child's development and behavior, as well as videos or pictures. Children and their parents must know that this data is restricted and will not be used in other contexts. Even with adequate permission to observe and record these details, the information must be stored appropriately, to avoid misuses and eavesdropping.

2.3 Community Use Case

The procedure described in the previous sections is traditionally paper-based, requiring a lot of written material. In a typical set of 24 children, of which only 50% are observed, as much as 48 to 72 pages of forms are filled. In a kindergarten, this procedure is repeated in all the rooms, totaling more than 200 pages of gathered data. Moreover, all the visual and audio details are lost.

The subjectivity inherent to this process also requires that all the observers, usually the kindergarten teachers, receive an uniform training, allowing them to achieve similar interpretations of similar situations. This is only possible if the communication between them is open and regular, requiring several in person meetings.

Moving this information to an online service, such as a social network, will allow the observers to store and organize all the observation data in a single profile, combining video, audio and text data in the same observation procedure. This also makes it possible to communicate asynchronously with other observers, providing a valuable tool for subjectivity reduction and better overall learning.

3 THE TEOBS SOCIAL NETWORK

The interactions between observers (kindergarten teachers) is fundamental to provide a stimulating environment for reflection and discussion, essential to ensure low levels of subjectivity and to improve observers' skills. The EEL/DQP process expects several, face-to-face, meetings to discuss about the data gathered in all of its steps.

The social relationships established between the participants in this process (friendship, co-working, information exchange, ...) can be mediated by computers through the TeObs social network. Computer-mediated communication (CMC) gives the possibilities for asynchronous exchange of information, regardless of where participants are. The community is no longer defined as a physical place, but as a set of relationships where people interact socially for mutual benefit (Garton et al., 2006). However, this does not preclude face-to-face meetings, should the community decide accordingly.

MySpace, Facebook or Twitter are remarkable examples of social networks, connecting millions of people around the world. TeObs intends to be an audience specific social network, connecting kindergarten teachers and providing a constantly updated memory of experiences and previous knowledge. This can result in connections between individuals that would not be made otherwise and that can prove valuable for the overall process as well as for each participant training (Boyd and Ellison, 2007).

3.1 Social Interactions

TeObs is a web-based service that allow individuals to construct a public or semi-public profile within a community. Connections among participants are articulated through a list of other users, keeping in mind the ethical behavior and security concerns. Under this restrictions, each user is allowed to traverse their list of connections and those made by others within the system.

Each user can be in two broad status:

- Idle: the user is not currently participating in an observation project, having access to specific connections and to previous notes and contents;
- Active: the user is participating in an observation project, with mandatory connections to peers and to the external advisor (the supervisor).

Each role the user can have is associated to his experience level (Figure 2). The bottom layer is populated with members unable to perform observations without undergoing a training process – dotted circles. After acquiring basic skills, the member gets the observer status, able to perform observations autonomously (as long as following the predefined guidelines).

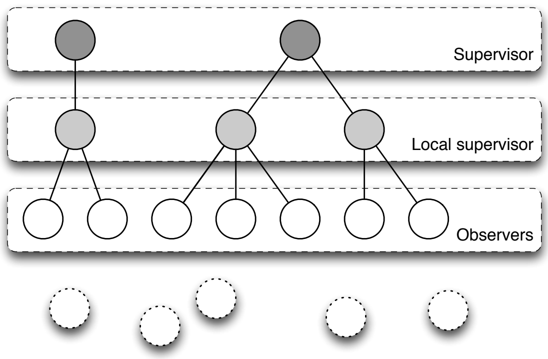

Figure 2: Community.

With increasing experience, the status may be elevated to experienced observer and, later on, to local supervisor. Finally, with complete domain of the observation process and with several successful projects, the teacher can become a full supervisor (Table 1).

An observation process starts with a supervisor creating a community and adding a number of kindergarten teachers. Usually, the community corresponds to an institution, although it is not mandatory. Next, the supervisor establishes the relationship between the community elements, granting or removing access to the data collected by each observer (Figure 3).

Table 1: Observer level.

4	Supervisor
3	Local Supervisor
2	Experienced
1	Basic training
0	No training

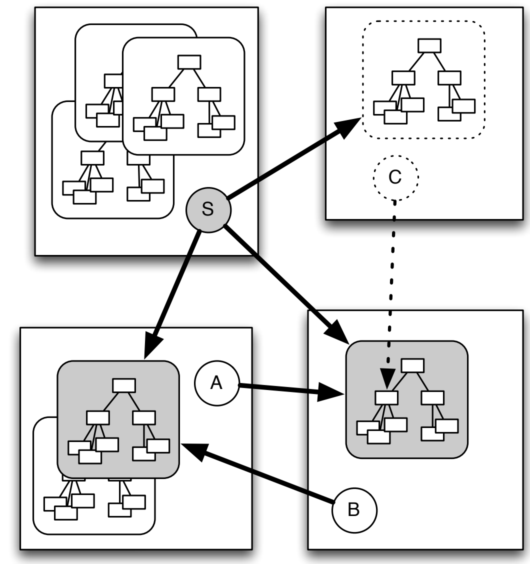

Figure 3: Social relations in an observation process.

Each observer, identified by a circle, collects and organizes information, stored in his personal area (the large rectangle). The observation data is structured as a tree, enclosed in a round rectangle. Each observer has full access to his area and all the data elements within. To reduce subjectivity, it is important that the data is shared with a peer and with a supervisor, to ensure similar criteria among observers. Sharing is configured by the supervisor, granting access to some information. In figure 3, the supervisor 'S' has access to the current procedure (gray round rectangles), the observer 'A' has access to the data collected by 'B' and vice-versa.

Each observer can also have data from previous procedures (white round rectangles). This is private information and is only shared with the supervisor and the observers of the same community at that time – 'B' and 'S' may not have access to it.

When starting a new community, the supervisor can invite a non-trained observer (dotted shapes in the figure). He is not able to contribute with observation data without acquiring basic skills so, the first step is to go through a training process. Other than "brick-and-mortar" training, observer 'C' may have access to specific data from other observations, granted by the supervisor, as well as other materials. He must be familiar with the team members, their perspectives and pedagogical practices so that among peers could be developed positive interactions.

The data, the social relations as well as the experience level is instantiated in a web-based, online application, which we call TeObs.

4 STRUCTURE AND IMPLEMENTATION DETAILS

TeObs is built in Java Enterprise Edition, following an multitier architecture structured in three functional layers (Figure 4):

- Data Model – responsible for data persistence and structure;
- Business Layer – library of actions available to upper layers and external applications, such as web browser, smartphone or desktop user interface;
- Web Layer – Web browser interface with the user.

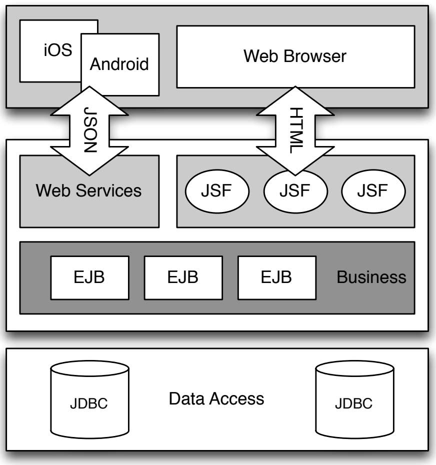

Figure 4: Multitier architecture.

Each layer is self contained, allowing the encapsulation of functionality and the distribution of resources to better cope with peak usage patterns or the increase of the number of users. This approach allows to build large-scale, scalable, reliable, and secure applications as well as simplifying the development of complex, distributed applications. The existence of a representational state transfer (REST) communications API allows integrating external applications, running in smartphones, for example (Mesquita-Pires and Lopes, 2014).

4.1 Data Management

As mentioned above, the observation process in the EEL/DQP project is implemented in three procedures: the Child Tracking Observation Schedule, the Child Involvement Scale and the Adult Engagement Scale. The observation details are registered in forms, structured according to the type and nature of each field. The EEL/DQP defines several fields, such as the institution and the observer name, the date, time, and the child's name, sex and age. In addition it also records the number of children and adults present during the session, the child's level of initiative (1 to 4), learning experiences, involvement (1 to 5) and interaction, among others (Mesquita-Pires and Lopes, 2014).

At a macro level, the procedure is structured hierarchically, in which an observation has several sessions and each session has many activities. Considering the structure and the nature of each data field as well as the associations between data entities, the structure of information in this situation is represented as five entities (Figure 5). The AES prefix indicates Adult Engagement Scale specific data.

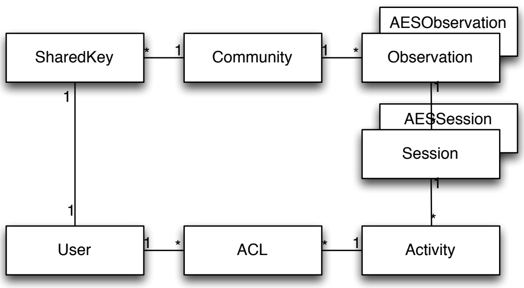

Figure 5: Entity diagram.

4.2 User Management

All the actions and data in the TeObs Social Network are associated to and belong to a specific user. In this context, users represent human agents that use a network service. He has to be identified, through a username, and authenticated using a password. This information is organized in specific entities (Figure 6).

The password is stored in the database in the form of a unidirectional hash, so that even if the password table is compromised, the attacker will not be able to decipher it. The entity `Certificate` stores the user's certificates, containing the public key necessary to protect the information he gathers.

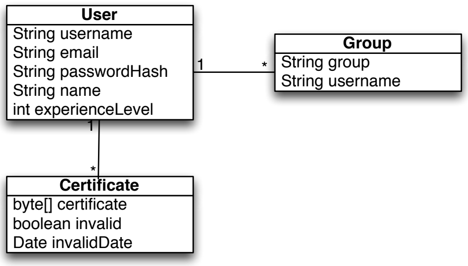

Figure 6: User elated entities.

5 SECURITY ISSUES

The ethical behavior inherent to all observation procedures demand rigorous security measures. In particular:

- Users must be authenticated;
- Data must be kept private;
- Users must be authorized to perform an action.

Each of this points depend on different mechanisms. Authentication is performed through the identification of a user and verification. Privacy is ensured through cryptography, both symmetric, to cypher data, and asymmetric, to deal with the key distribution. Finally, authorization depends on access control, through an Access Control List.

5.1 Authentication

Before any user is allowed to perform any action, he has to be authenticated or, in other words, his identity has to be confirmed. This is performed in three possible ways: using something the user has, something he knows or something he is or does. We chose to authenticate the user through something he knows – a password.

To make password cracking more difficult, we add a salt to each password (Wagner and Goldberg, 2000). The salt is a sequence of characters, generated through a Cryptographically Secure Pseudo-Random Number Generator (CSPRNG), that causes the hash to be different even is situations where the password is the same. The salt is stored in the user table alongside the hash (Figure 6).

The procedure to store a password requires that a random salt is generated, using a CSPRGN. Next, the salt is concatenated to the password characters and the hash is computed, using the SHA256 algorithm. Finally, both the salt and the resulting hash are stored in the database.

When accessing the social network, the user is requested a password. Since only the hash is stored in the database, password validation require:

1. Retriving the user's salt and hash from the database;
2. Prepending the given password with the salt;
3. Computing the SHA256 hash;
4. Comparing the resulting hash with the one from the database.

If both hashes match, the user is authenticated. Otherwise, the password is incorrect. To ensure privacy, users also store their certificates in the system, making the public keys available to other users and to the system.

5.2 Privacy

Data has to remain confidential, regardless of where and how it is stored. The nature of the TeObs Social Network requires the existence of a rigid privacy policy as well as a verifiable consent from a parent towards the protection of children's privacy and safety online. In this situation, privacy is achieved through cryptography.

All the observation material is cyphered before storing, so that it remains protected against disclosure. However, data should not be prevented to be shared between authorized members, although it should be completely protected to a third party.

Traditional cryptography falls under symmetric, where the same key is used to cipher and to decipher, and asymmetric, also knows as public key cryptography. This uses two keys: a private and a public. One of the keys is used to cipher and the other to decipher. In TeObs we use symmetric cryptography to cipher data and asymmetric to distribute the shared key (Figure 7).

When starting a project, the supervisor (the gray circle with a 'C') creates a new Community. The process starts by generating a key, which will be ciphered to the supervisor's public key (black key from the Certificates repository), and stored in the KeyStore. Only the supervisor (or another element through delegation) has the possibility to add members to the community, automatically creating a relationship with him.

When a new observer is added to the community, the shared key is deciphered (using the supervisor private key), ciphered to the public key of the new observer and stored in the KeyStore. Prior to data gathering, the observer retrieves and deciphers the shared key from the KeyStore. All the data is then ciphered

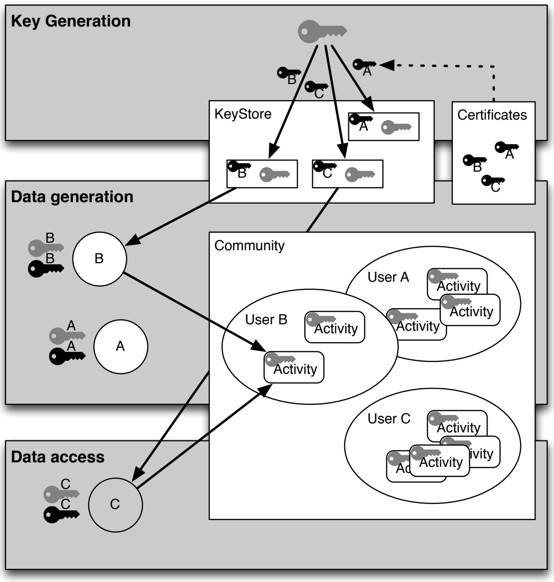

Figure 7: Key management.

and stored in the Community, ensuring that only the members have access to the content.

In other words, each community will have a single, specific, shared key. Although simple, this reduces the risk of compromise the keys, since no key exist before the start of the procedure and it changes with the community. At the same time, the data is secure from eavesdropping, even if all the database and all the stores are attacked.

To protect data against unauthorized or improper modifications, each community member digitally signs the piece of information submitted to the Community with his private key. This allows confirming the ownership as well as the integrity of the data.

5.3 Authorization

Cryptography protects privacy and integrity of information, as described above. However, enforcing protection also requires that every access to a system and its resources be controlled and that all and only authorized accesses can take place (Samarati and de Vimercati, 2001).

Access control models are generally concerned with whether subjects (any entity that can manipulate information), can access objects (entities through which information flows through the actions of a subject), and how this access can occur.

In the TeObs Social Network, the concept of Community defines the members with privileged access to information. However, further, fine grained, access control policies are necessary. Considering the previous social interactions, we have several access profiles (Table 2).

Table 2: Access profiles.

N	No access
R	Can read
W	Can write
R/W	Can read and write
D	Can delegate access

Considering a community member as the subject and the data as the object, the possibilities of access include reading, writing or delegating control, as summarized above. The relation between the subject, the object and the associated actions define the access control policies, which will have to be met by the security mechanism.

This approach is designated by Discretionary Access Control (DAC), based on the identity of the requester and on access rules stating what requesters are (or are not) allowed to do. This is instantiated in an Access Control Matrix, a three dimensions matrix relating subjects, objects and actions (Lampson, 1974). However, since this matrix is very sparse, it is not very efficient to be stored directly. An alternative implementation allows storing the matrix by column, defining Access Control Lists (ACL).

ACL are associated with the objects, registering who has access to it and how. In TeObs this is stored as an entity associated with the `Activity` and the `User`, in a many-to-many association (Figure 5). The ACL will have an entry for each user with access as well as the authorized action (Table 3).

Table 3: Access Control List.

Activity 1	
User A	R
User B	R/W
User C	R/W/D

The ACL builds on top of the privacy mechanism to further define the security policy. This allows restricting the possibilities within the community, allowing or denying specific members specific actions. For example, an user may read, write or delete information although another may only read it.

Each user is responsible for defining each activity's ACL. However, he can also delegate this function to other user, allowing the supervisor, for example, to update it.

6 CONCLUSIONS

Quality in education depends on the teachers' professional development, enhanced by observational research in preschool environment and sharing and working in a community of practice. Traditionally, this community is based on face-to-face discussion and exchange of experiences. This learning organization can be instantiated in an online social network, where communication is mediated by computers.

A web based community allows enhancing communication processes between members, particularly out of regular teaching periods. Moreover, it allows the integration of professionally isolated teachers.

In this paper we propose an observational research social network for preschool education, where the interactions between members are maintained and extended with the possibility for asynchronous communication. Moreover, a database of previous knowledge is also available, allowing better training and further studies.

Ethical behavior is fundamental, particularly privacy and access control. Cryptography is used for ciphering information and for key distribution and discretionary access control is used to specify the information each user can access and associated actions.

This social network is complemented with smartphone application for gathering and exporting data, as well as web pages for overall process management.

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Educating the Future with Disruptive e-Learning Solutions

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Keywords: Disruptive Innovation, Disruptive e-Learning, Discovery Driven Planning, MOOCs.

Abstract: e-Learning is having a strong impact on Higher Education. It is reinventing approaches to education and is causing sharp debates among its practitioners about the future direction of learning. Advocates argue that e-learning is a viable option to combat the high cost of higher education; that it extends educational opportunities to a greater number of students; that it trains students for the emerging Knowledge Economy. In fact, the e-learning education market has seen a continuous influx of new players; not only are traditional universities going online, but for-profit universities are emerging, some having a global reach, and most recently MOOCs (massive online open courses) that are offered as online education for free—many from elite universities that were the last to go online. These developments have created debates over assessment and accreditation. Educator Clayton Christensen calls e-learning "the great disrupted" that is transforming the higher education landscape. Yet even with the steady increase of e-learning options, e-learning is still regarded as inferior to traditional forms of learning. Critics regard is as too business and vocationally orientated, unmindful of questions of quality. This paper looks at some of the issues surrounding the controversy of e-learning options and makes some recommendations as to its improvement.

1 INTRODUCTION

e-Learning has challenged fundamental assumptions about how we learn and what we learn; how learning is to be delivered and how accessed. It has even opened up a sharp debate about the purpose of education; the values for which it stands and the competencies that it aims to teach. To quote Harvard Business School Professor Clayton Christensen, e-learning is proving to be the great disrupter of traditional education reinventing approaches to learning (Christensen and Eyring, 2011; Christensen, Horn, and Johnson, 2011). The process is already underway and appears to be accelerating. The reasons are not difficult to find. Caught between the pressures of rising higher education costs, the need for high level skills for the emerging knowledge economy, and rapid technological advances, new learning approaches are being invented that seek to take advantage of technological innovations and shape them into credible learning tools. E-learning has benefitted from this trend and has sought to present options that are viable and offer innovative solutions at lower cost and engaging forms of delivery. Increasingly new methods and approaches are being explored by this media: hybrid learning, virtual learning, mobile learning, and most recently MOOCs. At Riga Technical University in Latvia, the eBig3 project combined the communication technologies of computer, mobile, and TV to gain broad public interest. Most recently the project also offered MOOCs (ERDF, eBig3). But education via technology has incited much controversy as well as debates over the direction of education in general. Provoking such fundamental questions as: is technology learning too business orientated? What about humanistic values? What about quality? Is traditional education too elitist? Should education be more vocationally orientated? Or can we somehow combine some of these values or even should we? Its advocates claim that technology promises a fantastic future for educational engagement. Technology based learning, however, is too new for longitudinal studies; at this point, positive studies seem to generate critical studies and vice-versa. Yet the technology will not go away; it continues to spew out innovations apace. Therefore it is worthwhile to look at Clayton Christensen's--one of the most respected e-learning advocates--arguments supporting e-solutions. He claims that prevailing trends signal that online options are the inevitable future of higher education (Christensen and Eyring, 2011: 328). Christensen has outlined his ideas in considerable detail. These recommendations are worth looking at although by no means do they settle the controversy.

2 CHRISTENSEN'S DISRUPTIVE E-LEARNING

Clayton Christensen is the author of "Disruptive Innovation", a theory that he first outlined in the *Innovator's Dilemma* (1997). He had originally meant it to apply to business (he holds a joint appointment at Harvard in technology and management). The idea had come out of his dissertation, and he had meant it to apply to the disk drive industry. But the idea was quickly co-opted; many managers believed the process described their own experience. Christensen came to realize that "Disruptive Innovation" described a general business model. And because he was engaged with computer technology, he recognized that the model also applied to e-learning. The way disruptive innovation works, is that it is applied in areas where there is no competition. Slowly, and out of sight the company / organization improves its product. Soon there is an alternative product on the market that is cheaper and of better quality than the dominant one; and if the alternative product is more attractive to consumers, the dominant product can be toppled. This is what happened to Kodak with digital films, or how Cannon managed to trump Xerox or Sony with its transistors clobbered RCA's vacuum tubes. Christensen cautions against taking major competitors head-on--a good way for a company to get bloodied. Instead, he claims, disruptive innovation works against non-consumption—it stakes out a new territory—and improves its product step-by-step. When by its success a product or an approach is shown to work, it becomes a *fait accompli* and may even come to dominate the market (Christensen, Horn, and Johnson, 2011: 141) As applied to e-learning, Christensen refers to it as "disruptive e-learning." It is the crux of his strategy for effective education that is democratizing and can reach almost anyone. He believes that disruptive e-learning can bring about student centered learning that he argues is the focus of quality teaching. He is opposed to traditional learning because he regards it as a monolithic, top-down approach or teacher-centered and refers to it as batch learning (Christensen, Horn, and Johnson, 2011:175). Christen argues for a modular course design where the parts are interchangeable. He also calls for modified "majors" where students may become experts in several areas instead of concentrating on one and where independently designed course "modules" allow them to move easily between different subjects. Microsoft is an example of the "batch system", the programs are interdependent; they are part of a system. If you use one, you must use the entire system. Moreover, they are expensive to build. Simplify—argues Christensen—the byword that informs his disruption strategy. He claims that a simplified modular architecture such as offered by Linux allows for the building of separate modules. It is cheaper and more flexible and the heart of disruptive design. Its simplicity and low price allow it to be customized by users. A modular approach also gives students the flexibility to move on to the next module without wasting time on concepts and materials they already understand. It is an important option for bringing about student centered online learning. The next step in this strategy is to make use of popular apps and user generated content. Among these are those generally well known to the public such as eBay, YouTube, Pixar for digital animations, and Second Life for 3D applications. He recommends technology platforms that are suitable even for nonprofessionals such as QuickBase for designing user generated content. Parents and teachers can develop programs that will help their children learn. This mixture of disparate content, he argues, can have wider application because it can become the basis for shaping successful e-courses. Central to this thinking are teacher and student networks such as teacher online sites to exchange information and lesson plans and student self-help and tutoring sites, such as Megastudy in South Korea (Christensen, Horn, and Johnson, 2011: 134-145). Mentoring, but especially peer mentoring, is central to Christensen's concept of student centered learning. Christensen, like many teachers, feels that students have difficulty in grasping the relationship between theory and practice; that they memorize a theory but have difficulty understanding how it may be applied to real life solutions. Peer mentoring, he feels, can help students break down complex ideas and show how they work in various real-life contexts. Peer support is especially important for at-risk students who may feel stressed by academic materials. A number of the peer support sites are available online, and Christensen feels they should be included in an e-course design. Christensen admits that this disparate, user-generated content looks more like tutorial tools rather than courseware, but over time, he claims, these modules can be configured into complete courses. Disruptive innovation starts small and gradually builds up as the demand increases. It is a grassroots approach to e-learning that expresses an intriguing departure to standard academic learning.

Since disruptive innovation never applies the head-on attack, Christian recommends that this user-generated learning should take effect on the fringes. He points out that innovations when officially presented are often co-opted by organizations and rendered innocuous by official policy or pulled apart in turf fights. Instead, he suggests, disruptive e-learning should take root in places where there is a "consumption gap." Students re-taking courses to fill a "credit-gap," home bound schooling, assisting at-risk students, tutoring and enrichment programs, or making available courses that cannot be added to the curriculum because of budgetary constraints. Rural, small schools, urban low-income schools, could benefit from such an approach. This e-solution is an alternative when there is nothing at all and is a case in point how disruptive innovation, or in this case disruptive e-learning, is embedded into a system and can provide an alternative, a richer education experience than the one that existed before. The learning of the future, Christensen predicts will be driven by student-centered technology innovations (Christensen, Horn, and Johnson, 2011: 99).

3 HELPING AT RISK SUDENTS WITH DISTRUPTIVE E-LEARNING

Christensen is a dedicated social crusader. His Innosight Institute is committed to applying the transformative power of disruptive innovation to the social problems of the day. Educational reform at all levels he regards as crucial. He details the Pathway program at Brigham Young University at Idaho (Christensen is an alumnus of Bingham Young University, Utah and remains closely associated with the university's activities) as a model for upward mobility for the academically challenged and at-risk student group. It is an online program that requires weekly face to face meetings and encourages peer interactions. It reflects the indirect, non-aggressive approach of disruptive e-learning that is the cornerstone of Christensen's thinking. The Pathway program seems a sensible step by step plan for the inclusion of the academically challenged and socially and economically disadvantaged. Pathway runs parallel to the regular university curriculum. The standards of admission are low. It is intended for older, at risk students who need to support themselves and a family. The program designers understand that the primary concern of these individuals is the need to earn a living. The first part of the program offers technical competence courses in basic accounting, web media design, basic legal and library research, skills that are immediately marketable. Upon the successful completion of the program, students receive a certificate. They may then go on the next level that is an Associate Degree, and, if that is successfully completed, a Bachelor's (Christensen and Eyring, 2011: 315). It is a Matryoshka doll structure where each significant academic achievement is nested within the next. It gives students the option at the end of each learning level to finish or to continue to a more advanced degree while at the same time being able to provide for themselves and their families. The cost of a Bachelor's degree is about $8,000, a fraction of the cost what it would cost at a medium level, accredited university (What is Pathway).

4 THE WIDER IMPLICATIONS OF DISRUPTIVE INNOVATION

How relevant are Christensen's ideas today in the field of technological innovation? Jena McGregor claims very. In her interview with Christensen for *Bloomberg Businessweek* she describes him as is a giant in the field of innovation thinkers (McGregor, 2007). What has changed since 1997 when the *Innovator's Dilemma* was first published is that the landscape has gone global. It is in flux and the behavior of the players is unpredictable. Yet the notion of disruptive innovation still resonates although the model is felt to be too simple to explain this complex scenario. Moreover, Christensen did not originally provide a solution for his model; he only described phenomena that he had observed and that is now being played-out on a global scale. The Rita McGrath and Ian MacMillan model (McGrath and MacMillan, 1995) presents a method to structure phenomena when outcomes are uncertain and could be used to structure disruptive innovation. Traditional planning projected outcomes for projects; if the outcomes matched the projections, it was considered valid; if not, it was regarded as deficient. But Discovery Driven Planning seeks to promote innovation. It turns conventional thinking on its head. It encourages the new in a controlled way. Results are tested at benchmarks, assumptions are questions and articulated and then the next steps are planned from the results (McGrath and MacMillan, 1995). It means a commitment to continuous learning on the part of project managers. Moreover, just because an innovation is in place does not mean it will maintain itself in the future; instead it must be reassessed on an ongoing basis. Christensen feels when his ideas are combined with those of Discovery Driven Planning a sounder assessment of an innovation is arrived at as well as its potential for success (McGregor, 2007). These ideas could be applied to disruptive e-learning to give it a more structured development that at present seems erratic.

5 COUNTERING THE COST OF HIGHER EDUCTION WITH SUNDRY E-LEARNING SOLUTIONS

Currently, there are many emerging models for higher education. Most of these are online. Besides online courses offered by traditional universities, there are the for-profit universities mostly with online options, some of which have become global giants such as Laureate whose honorary chancellor is Bill Clinton (Redden and Fain, 2013). This development has also set up a credentials debate and proposals for alternative credit assessment. Even President Obama has entered the fray and made recommendations to combat rising college costs that include competency credit and MOOCs (Obama, 2013; Levin, 2013). Richard Vedder, author of *Going Broke by Degree: Why College Costs So Much* (2005), argues for a pro-business, no frills program that makes use of lower priced online options such as the new entrants MOOCs, a three year Bachelor’s program as in Europe, and most controversial of all, a National College Equivalence Test similar to GED for the High School Equivalence test (Vedder, 2013). Needless to say, such a reductionist program has elicited howls of protest from educational purists who claim that these HiTech reformers leave out questions of quality and the importance of education as an intrinsic value leaving only a thin vocational, pro-business veneer (Walters, 2013). Moreover, they point out that the proposed system of online reform would increase student / teacher ratio 50:1; a dramatic increase that is endorsed by pragmatists such as Christensen but decried by the quality advocates. Yet there are issues that reformers of all shades of opinion agree: (1) that higher education costs are too high; (2) that there is a proliferation of majors that are proving costly and often force students to postpone graduation to meet requirements; (3) that students are not prepared to deal with the requirements of university courses and need structured support embedded in the program (What is Pathway; Christensen and Eyring, 2011). These three points are the main challenges that must be met to achieve realistic educational reform. Technology must be a major driver, not only because it helps to reduce costs, but even more so because it gives students access to the emerging Knowledge Economy and its potential for innovation.

6 AND THE DEBATE GOES ON

In the mist of so much controversy the signals about the future of e-learning are mixed, although generally favorable for long-range growth. As many as 69.1% higher education institutions in the United States report that online learning is critical to their long term strategy (Allen and Seaman, 2013). In the United States where technological solutions to learning are most actively embraced, online learning has steadily increased over the past ten years, so that currently thirty-two percent of the students are taking a least one e-learning course. Yet last year there was a perceptible leveling off of enrollments, increases dropping from an 11.2% to 9.3% although university officials agree that online learning is critical to their long- term strategy (Allen and Seaman, 2013). Europe has been more conservative in adopting e-learning; in 2011 (published in 2013) for the EU-27, 11% of their populations (ages 16 to 74) were engaged in online learning. In the same time period, Latvia was one of the more active with 16% of its population (ages16 to 74) were engaged in online learning, exceeded only by its Nordic neighbors (European Commission, 2013). The most recent entrants to the technology learning market are MOOCs (Massive Online Open Courses). They have been touted as the next educational paradigm; yet currently there is a great debate if they are sustainable (Allen and Seaman, 2013). These are open access courses that cut across a wide range of disciplines including technology, philosophy and even music. Besides course materials that include various media formats, MOOCs seek to establish online forums and learning communities similar to what traditional e-learning courses already offer. An interesting development in this regard is that the elite universities that were slow to adopt online learning, were first to jump on the MOOCs bandwagon. Harvard as recently as 2013 and is currently engaged in developing its first regular online courses for the Business School—"we are being disrupted online," HBS claims (Nissen, 2013). There are online listings of elite USA universities that start with Harvard and MIT and include Apple's list that is a comprehensive MOOCs listing (MOOCs). Most of these use Coursera or Udacity or another popular platform. Currently there is much debate if MOOCs are sustainable. Academics generally think that MOOCs will cause much confusion about university degrees and credentials (Allen and Seaman, 2013). The shrillness of this debate indicates that there is indeed a transformation taking place and that the stakeholders have not settled on the terms of the outcome.

In spite of resistance and challenges, the statistics show a steady increase of e-learning for the future. Christiansen no doubt is right that it will lead to a disruption of traditional forms of learning as it already seems to be doing. Transformations are taking place that are affecting even the most highly respected Higher Education Institutions. Yet barriers and prejudices remain. Many people, including academics, resist accepting e-earning as the equal to face-to-face learning. Employers often regard it as inferior. Moreover, the record of the retention rate of on-line students has been poor. Many drop out before finishing the course (Allen and Seaman, 2013). It is possible that these students are academically poorly prepared and lack self-discipline although other studies have shown that the technology does not usually pose a barrier to the current generation of students, but rather they may lack motivation, study skills and have family responsibilities (Concannon, Flynn, Campbell, 2005). The immediate issues that need to be addressed in Higher Education reform is controlling the costs and making education more affordable—an issue that can effectively be addressed by e-learning. The second issue is about the proliferation of course for majors that often hold up graduation. Christensen's modular approach that is spread out over several disciplines seems far more sensible to replace the traditional major and gives students more options in planning careers. And finally, users who are at risk need help and support, including financial support; they need a gradual, clearly benchmarked program such as Pathway or another structured approach to be able to succeed in a e-learning environment.

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Revamping the Classroom
Teaching Mobile App Software Development Using Creative Inquiry

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Keywords: App Development, Creative Inquiry, iOS, Android, Smartphone, Tablet.

Abstract: Teaching mobile device software development is challenging. Almost everything about it is different from teaching a traditional software development class in which the target computer (on which the software developed by the students is to run) is a laptop or desktop computer. In a mobile device software development course, the target computer is a device (smartphone or tablet) that has a large number of features (Internet access, camera, GPS, gyroscope, media display, etc.) accessible by software. The material that must be covered in such as course is so broad that new approaches to delivering course content must be used. This paper describes the overall method by which we teach such a course. We describe four challenges and explain how we address each. We describe the structure of the course in detail, explain how a class policy of open collaboration and a university program called Creative Inquiry complement the proposed approach. We conclude with student evaluations and examples of apps we have produced over the past several years.

1 INTRODUCTION

Teaching app software development is challenging. Almost everything about it is different from a traditional software development class in which the target computer (on which the software developed by the students is to run) is a laptop or desktop computer. In a traditional object-oriented software development class, the focus is the programming language, how statements are formed, how classes and methods are constructed, and how object-oriented properties, such as inheritance, are brought to life in the program being developed. The focus is almost *never* the computer itself (laptop or desktop) on which the program will run. It is simply assumed that the program can read input files, take input from the computer keyboard or mouse, write output files and display output on the computer monitor.

In a mobile app software development class, the programming language is only the first of several major items that the student has to learn. The student must also learn how to use the interactive development environment (IDE) and the software development kit (SDK) specifically designed for the mobile device. This includes learning about different types of input and output touch elements (for example, buttons, sliders, and text boxes), working with different types of views (for example, table views, web views, views that allow for video), understanding new ways of providing input (such as gestures or speech), learning about new source streams of time sensitive or late-breaking information (such as Rich Site Summary, or RSS, and Twitter feeds) learning about maps, the global positioning system (GPS), accelerometers, gyroscopes, the camera both video and still, and on and on and on. Often apps must also work with app settings or an internal database to store persistent data. More advanced apps may also work with an external database, for example MySQL, that the app accesses through the web using web services written in *PHP: Hypertext Preprocessor* (PHP) or other scripting languages.

Teaching a one-semester course on mobile device software development is *significantly more challenging* than teaching a one-semester course on traditional computer science topics such as an introduction to programming, algorithms and data structures, compiler design and implementation, or operating systems. In courses such as the latter, the topic is well defined and narrow enough for the student to grasp and develop skills for in an evenlypaced and systematic manner. In a mobile device software development course, the material that must be covered is so broad that new approaches to delivering course content must be developed and employed.

This paper describes the method by which we teach a mobile device software development course. In Section 2, we explain in detail the challenges facing the instructor in this app development course and explain the approach we take in addressing these challenges. In Section 3, we talk about the structure of the course itself. In Section 4, we elaborate on the Creative Inquiry Program at our university and how it supports this course and helps generate ideas for app projects. In Section 5, we describe some of the apps that have emerged as the result of this effort. In Section 6, we summarize the results of student evaluations. In Section 7, we discuss future plans..

2 CHALLENGES / APPROACH

We find four major challenges facing an instructor of a mobile device app development course.

The first challenge arises due to the fact that the content is very new and also constantly changing. The Apple iOS™ and Google Android™ operating systems (OS), for example, are updated at least annually; keeping up with the major changes in the OS and the associated SDKs is difficult. Textbook authors, unfortunately, cannot possibly keep up; on the day that a textbook is published, the OS and the SDK it references are already one version behind the latest stable version. And so the first challenge is finding resources that can help the student learn about the latest version of the OS and SDK in a timely manner.

The second challenge is that the material that has to be covered is very *broad*. In iOS, this includes learning the syntax of a language, Objective-C, whose syntax is unlike any of the other more commonly taught languages such as Java, C++, C# or Python. A student wanting to take this app development course is unlikely to be familiar with Objective-C. (On the Android platform, this challenge is not as great since the language used for Android apps is Java which is known to many students.) On both platforms, however, new course material also includes touch input artefacts such as buttons, sliders, segmented controls, and date pickers as well as input finger movements such as gestures, swipes, and multi-finger touches. The material includes a variety of views such as web views, table views, and views that present video and animation, from and to which students will have to learn how to program transitions.

The course material must also include a variety of components and features of smartphones that are available for software control, components such as the still and video camera, the global positioning system (GPS), the accelerometer, a gyroscope, maps, and a compass. The material also includes new sources of streaming data such as RSS feeds and Twitter feeds. The instructor may also want to cover sending and receiving short message service (commonly called SMS or text) messages, or sending and receiving email. Yet another content topic that the instructor may want to include is graphics for animation, using OpenGL for example.

The third challenge is how to have a discussion of good database design and implementation. An app may require a local database that resides in persistent memory on the mobile device, or may communicate with an external database that resides on a server in the cloud and accessed via web services. In many instances, both an internal and an external database are required. Unfortunately, in many computer science programs, a database design course is an elective and not required. If such is the case at your university as it is at ours, then a minimum of one to two weeks of lecture will be required to introduce very basic database design concepts to allow for an internal and external database implementation in the app.

The fourth and possibly the most difficult challenge is how to make the course relevant, i.e., how to make the course as close to professional app development as possible. Our goal was to avoid having the students develop *toy* apps that have no purpose other than as an exercise in programming. How do we give our students an experience that is close to real world app development? How do we provide students with app ideas that have real-life application? The challenge was to find projects that would give our students this type of experience. We found our answer in *Creative Inquiry*, a university-wide program designed to give undergraduate students experience in designing and developing solutions to research problems posed by faculty members, researchers and staff.

These four challenges require us to *rethink* the manner by which we teach this course. The approach we have chosen (which we detail in Section 3) is a variation of the “flipped” or the “inverted” classroom (Walvoord and Anderson, 1998; DesLauriers, Schelew, and Wiemanm, 2011). This variation consists of a combination of (a) minimized lecture on the part of the instructor, (b) open collaboration among the students, (c) frequent student presentation of programming assignments, and (d) close mentoring of the semester projects.

In order to minimize instructor lecture, we had to find resources with which students can work outside of class. Examples of these resources are listed in Section 3.2.1. Students are expected to view these video clips or tutorials *before* coming to class. Proponents of flipped classrooms suggest that allowing the students to gain what is referred to as *first-exposure learning* on their own before class and then working on applying their learning during class can in certain situations be more effective than traditional lecture. To be effective, an assessment tool, such as an assignment on the material the student learned, must be included. In our case, the assessment tools are the four assignments described in Section 3.2.3.

Where our approach differs from typical flipped classrooms is in “open collaboration”. The purpose of open collaboration is to facilitate the exploration of as many facets of the SDK as possible. Students are encouraged to include different app components (compass, gyroscope, camera, GPS, etc.) in their assignments and to share their knowledge with the rest of the class. This is accomplished by requiring each student to maintain a personal website on which he or she posts URLs of sites that they have found helpful. More importantly, the student posts copies of his or her programming assignments (complete with source code) when they are submitted. Students are free to discuss and share their programs before and after submission. Moreover, after each assignment is evaluated, the instructor selects the two or more best programs and asks the students to give a brief (10-minute) presentation to the rest of the class, focusing on the new app components employed and describing the corresponding source code. Students in effect teach each other what they learned as they developed their assignment. This is further discussed in Sections 3.2.2 and 3.2.3.

The fourth challenge is making the course relevant. We are fortunate at our university to have what is called a Creative Inquiry (CI) program that encourages faculty to design one to three credit hour courses involving undergraduate students in the faculty member’s research. So, for example, an English professor may be working with students in studying the writing of British author Virginia Woolf. A Biology professor may be interested in engaging students in the study of swamp forests. An Entomology professor may have his students researching whether firefly populations are decreasing. These and many other CI courses are opportunities for collaboration with our app development class. The instructor contacts the instructors of these CI courses and discusses the possibility of developing apps supporting these CI efforts. Sometimes a natural collaboration between our app class and the CI course emerges, sometimes it doesn’t. When a potential collaboration does emerge, the app class instructor must facilitate the matching of one or two student app developers and the CI course. We devote Section 4 to the Creative Inquiry program that has provided support and a rich source of ideas for this course, helping us respond positively to the fourth challenge above.

3 APP COURSE STRUCTURE

In this section, we describe the organization of our app development course (henceforth referred to simply as *X81*, short for CPSC 481/681, the official number of the course). In *X81*, the semester is divided into two parts. The first half of the semester is spent on four programming assignments of increasing difficulty, with the requirements of each assignment being a superset of the previous. In the second half of the semester, the students work on a major project. The project starts with the students submitting a proposal for a project. After the project is approved, the remainder of the semester is spent on the design and implementation of the software system.

During exam week, students formally present their results in a class mini-conference. With the course instructor serving as session chair, students give 20-minute presentations and demonstrations of their apps, just as they might at a real conference. All are invited and project co-mentors, other students, faculty, staff, and occasionally family members do attend. At the end of exam week, students submit the entire project (source code and documentation) for a final private demonstration to the course instructor and for final evaluation.

Each of these course components is described in detail below, but we start with an explanation of the choice of mobile device platform.

3.1 IOS, Android or Other?

A recent Nielsen poll in the US (Nielsen, 2013) gives Android a 52% to 40% smartphone market share edge over iOS. Another poll (Business Wire, 2013) gives Android a 79% to 13% edge over iOS worldwide in the 2nd Quarter 2013, suggesting that

Android is surging and significantly surpassing iOS. The takeaway from this is that Android and iOS together dominate the smartphone market in 2013.

We are *not* concerned about whether Android beats iOS or vice versa. In *X81* we cover *both* platforms (iOS in the fall semester and Android in the spring). What is important to us is that we cover the *dominant* platforms in this course. We keep track of trends, however, and should another platform (say, Windows) become a significant player in the mobile device world, we will adapt this course accordingly.

3.2 First Half: Building Skills

3.2.1 Gathering and Updating Materials

The first challenge listed in Section 2 describes the difficulty of finding a textbook or other materials that teach the student about the latest version of the mobile device OS and SDK. For the course, we use online materials, including videos, tutorials, sample code, and other online resources.

For example, for iOS, in addition to the comprehensive developer reference site provided by Apple (Apple, 2013), we use the video series provided by Paul Hegarty and Stanford University available on iTunes (Hegarty, 2013). For Android, in addition to the comprehensive developer site provided by Google (Android, 2013), we use sites such as Nick Parlante's (Parlante, 2011) course outline that provides tutorials on topics such as intents, lifecycles, lists, GUIs, and databases.

In addition to these, throughout the semester, we constantly search the web for new and better video or text tutorials that provided instruction on the latest version of the OS and SDK. Students in the class are tasked with seeking and reporting new sites that they find useful in developing their apps. By doing so, the class collectively and continually keeps the set of course resources up-to-date and available to the entire class through the class website maintained by the instructor.

3.2.2 Individual Student Websites

Students are required to create and maintain individual websites specifically for this class. On each website, students post links to resources that they have found useful in developing their apps. They also post the source code of each programming assignment they submit. This is so that their code is available for download by *other* members of the class. This is part of the class policy of *open collaboration* that is explained further in the next section.

3.2.3 Assignments and Open Collaboration

In this class, student home and class activity consists of (a) viewing video and tutorials providing detailed instruction on app development, (b) submitting four apps satisfying four programming assignments, (c) when asked, giving brief (5-10 minute) impromptu presentations about his or her programming assignment pointing out where in the source specific actions in the app are coded, and (d) sharing ideas about interesting things he or she may have discovered along the way.

The assignments are of increasing difficulty. The first assignment asks the student to build an app with several input controls (for example, buttons, sliders, or text boxes) several output controls (for example, labels, alert boxes, or images such as check marks or smiley faces corresponding to calculated results) and some activity that occurs when the client touches an input control.

An important class policy is: whereas in other programming classes, students are often forbidden from working together and certainly never allowed to copy one another's code, in this class students are not only allowed to copy each other's work but are *encouraged* to do so. The one requirement is that if a student develops his or her app with the explicit or implicit help of another, the recipient must explicitly *acknowledge* the other student's help and give credit to the other both on the recipient's website and in the information page within the app. Giving credit for help received is *mandatory*.

The rationale behind this policy of *open collaboration* is that in a given assignment, different students will go in different directions and use different tools within the SDK. Discussion about their apps in and out of class is strongly encouraged. Copying code is allowed and encouraged. In this manner, students quickly learn multiple features of app development from their peers. The tacit expectation, of course, is that *every* student brings something new to *contribute* to the class collective repository of knowledge.

The second assignment includes all the requirements of the first app and must include multiple views (for example, table views, web views, or views that play audio and video). The third assignment must include a local database created and populated using SQLite3, a commonly used internal database for apps. The fourth assignment has all the requirements of the third assignment, plus it must involve an external database, preference settings and two additional features such as GPS, the video or still camera, the accelerometer, the gyroscope, or must capture input from some external device such as an automotive on-board diagnostics (OBD2) sensor which can provide the vehicle owner or repairman or app developer with the status of various vehicle subsystems.

By the time Assignment 4 is submitted, the semester is half over.

3.3 Second Half: Major Project

The second half of the semester is spent on the proposal, design, and development of a major project.

3.3.1 Project Proposal

Students may submit an original proposal or may select a proposal from a list of ideas provided by the instructor. The one-page proposal is intended to be a brief overview of the project and is the starting point of a discussion between student(s) and instructor. The result of the discussion is a resubmission of the proposal with more detail and with a fairly complete storyboard sketch. There exists software available for free that facilitate storyboard development producing mock-up views that look very much like actual screenshots from a smartphone. An example is Fluid (Fluid, 2013) that provides a software tool for quickly and easily building mock-ups of apps.

The student has the option of proposing a project that he or she may be interested in. Students are encouraged to submit ideas that relate to and benefit the university and campus life. So, for example, a proposal to develop an app that expedites orders at a local pizza restaurant would not be approved. However, a proposal to (1) help newly arrived international exchange students get around campus using an interactive campus map, (2) complete all university requirements for international students, and (3) communicate with one another and with the international student office through SMS and phone numbers stored in internal and external databases, this type of app proposal would be approved. (A screenshot of this app is found in Section 5).

Most students, however, do not have a pet project in mind. A list of ideas offered by the instructor is the result of interaction with university faculty, researchers, staff and administrators interested in participating in the Creative Inquiry program. Throughout the first half of the semester, the instructor meets with various university personnel (potential co-mentors) and discusses the possibility of collaborating for the purpose of developing an app for the co-mentor and his or her students. The co-mentor and students provide the project content; the *X81* instructor and students provide the technical expertise. The list is the result of this consultation with several faculty and staff and is offered to the *X81* students as pre-approved projects.

3.3.2 Timeline, Database and Code Design

After the proposal is approved, the students develop a project timeline or schedule of tasks and deliverables. The instructor reviews this timeline, critiques it and returns the modified timeline to the students.

After the timeline is approved, database and code module design begins. The app may require both an internal and an external database. Final approval is given only when the instructor is convinced that all of the functionality proposed for the app can be supported by the structure of the internal and external database.

3.3.3 Presentations

Over the next three weeks, each project team gives three short (10-minute) presentations and one full (20-minute) final presentation before the class, reporting on the current status of their work. The instructor and class critique the presentation as well as the content of the project, offering suggestions for improvement or alternative approaches. In this manner, each team has multiple opportunities to refine their presentation skills as they develop the app solution to their problem.

The final presentation occurs during exam week. Co-mentors and students, interested faculty and staff, and family members attend. The instructor serves as session chair and introduces the student speakers, as they would be at a real conference. Every attempt is made to simulate and provide the students with a formal conference experience, including a soda and pizza reception at the end.

3.3.4 Final Demonstration and Submission

After the final presentations, student teams are required to meet with the instructor one last time to give a final, private demonstration of the software and to submit all source code and supporting documentation. The documentation includes a Technical Reference Manual and a User's Manual, the presentation slides, and any other supporting documents. Students have been instructed to develop the User's Manual using language understandable by a non-technical user of the app. The Technical Reference Manual, on the other hand, is for a computer science student who may want to extend the app in the future.

4 APP IDEAS: CREATIVE INQUIRY

The students are always given the opportunity to propose projects for which they are interested in developing apps. The one requirement in this class is that the app be one that is designed to benefit students, teachers, staff, administrators, or other personnel in an academic environment. The app must help students learn or teachers teach or make life better for someone in the academic community.

Coming up with a list of suitable projects is not easy; they must satisfy several course goals. One course goal is for the project to take advantage of the features of the mobile device. Another course goal is for the project to be generic, i.e., ideally adaptable to any university or institution, not just our university. A third goal is for the project to be upwardly scalable, i.e., capable of being initialized with and holding additional content.

Once a list of potential projects has been identified, matching the right students with the right projects is crucial for success. It is for this reason that we have worked with a university program called Creative Inquiry to help us identify projects and involve other faculty, researchers, staff, and administrators as co-mentors of course projects.

Section 4.1 describes the general Creative Inquiry program. Section 4.2 explains how Creative Inquiry has helped provide app ideas and projects for *X81*.

4.1 What Is Creative Inquiry?

Clemson University's Creative Inquiry model for undergraduate research provides students with team-based, collaborative research experiences that address real-world problems and prepare students for jobs in the changing economy. Graduates have stated that they were better prepared for jobs or graduate school, and more attractive to employers. Students in Creative Inquiry have developed business plans for start-up companies and participated in patent applications, in addition to presenting and publishing their work.

The model develops teams of students to address topics identified by the faculty mentors, the students, or that are spurred by external influences. Each project is embedded within one or more academic courses. Projects may be multi-disciplinary. Teams work on a given project for two or more semesters. Some projects have a natural end point; others continue to evolve for many years. For example, a performing arts team dedicated two years to developing and producing an original play. Several English and Social Sciences teams have collaborated on books. An award-winning interdisciplinary team - with students from engineering, business, and the humanities - has worked for several years to boost economic development and the standard of living in a Haitian village. Their signature project was designing and installing a water system for the village.

Each academic year, approximately 3,500 Clemson undergraduates participate in Creative Inquiry projects. Departments, such as food science and geology, use Creative Inquiry to attract and retain Others departments, such as industrial engineering and bioengineering, use it to in concert with their senior design and freshman courses. Students in all departments praise their experiences as valuable in terms of the research accomplished and the opportunities to gain insights into potential careers.

Creative Inquiry is sustained by high levels of student and faculty interest, substantial funding from the university, and a demonstrated record of accomplishments within both the academic and business worlds. The program has grown to the point that private donors and industries are sponsoring student research teams. A key feature of the program is its flexibility. Projects from all disciplines are supported. Students are encouraged to develop ideas for projects and then identify faculty mentors to refine the ideas and mentor the work.

4.2 How Co-mentoring Supports *X81*

X81 is classified as a Creative Inquiry course. As such, it enjoys financial support from the university; this support is used to purchase mobile devices to be used in the class, or pay hourly wages to students who have taken the course before and who can serve as teaching assistants. More importantly, though, other members of the university recognize and support the Creative Inquiry model and are more willing to participate in co-mentoring a Creative Inquiry project.

A typical project involves one or two faculty members plus one or more of their students, *i.e.* the

X81 instructor plus one or two *X81* students. For example, one project last year involved an English professor and avid researcher in the works of British author Virginia Woolf. The English professor had eight students working with her in gathering and organizing material associated with Virginia Woolf. These included maps where Woolf lived and worked, pictures of British houses she lived in and London gardens she frequented, articles written about Woolf, essays critiquing her work, lists of websites where one can gather more Woolf information, and even copies of ledgers of daily household expenses that Woolf and her husband maintained.

Two *X81* students undertook the technical development of an app that organized the material gathered by the English professor and her students. The final version of the app presented the content on an Apple iPad in an efficient, easy-to-use, and intuitive manner. The English professor and the *X81* instructor served as co-mentors of the entire group with one guiding the software development process and the other guiding the organization of the content. The results of the effort were presented in an international conference on Virginia Woolf last spring (Sparks and Pargas, 2013).

5 RESULTS

The proof of a pie is in the eating. The proof of a course on mobile app software development is in the apps that are produced. Over the past two years, students have successfully produced over 30 iOS and Android apps.

Figure 1: Three sample apps produced by X81 students.

Three examples are shown in Figure 1. In the upper left, *iCUExchange* is designed to help international students prepare for their study at this university. The app was designed by three international exchange students and provides helpful information before and after the international students arrive on campus, including important deadlines, contact information, tips on getting around the campus, finding classrooms and getting to know other people. In the upper right, the *Virginia Woolf* app is designed for people who want to be able to access a mobile collection of photos, documents, and general information about the British author. The app serves as a knowledgeable portable tour guide. The bottom app, *R3-ROS Robot Remote*, provides an iOS user with an interface to control robots (represented by cubes) within a virtual world. The app uses the gyroscope and motion sensors of iOS devices to control the robots.

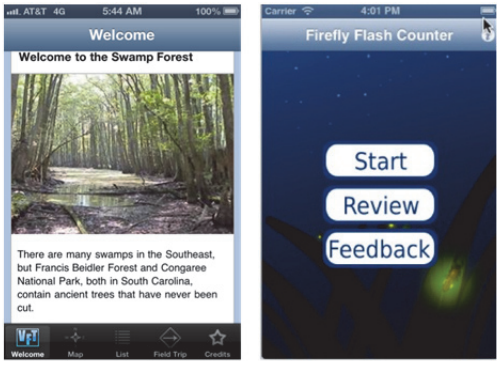

Figure 2: Two apps available at the Apple app store.

In some cases, development of apps start out in the classroom but continue after the semester is over and eventually are made available to the general public. Two examples are shown in Figure 2. *Swamp Forest*, shown on the left, provides a virtual field trip through the Francis Beidler Forest and Congaree National Park in South Carolina, USA. This and two sister apps, *Cove Forest* and *Salt Marsh*, are all available at the Apple app store. The Firefly Flash Counter, shown on the right, is also available at the Apple app store and is used by citizen scientists around the USA to count fireflies as part of the Vanishing Firefly Project 2013 (Baruch, 2013). In total, six iOS apps originating from this course are now available at the Apple app store and one Android app will be available on the Google play store in spring 2014.

Undoubtedly, instructors at many universities have developed app development courses with approaches similar to this course (e.g., Muppala, 2011). We feel, however, that this course is different from others with its policy of open collaboration and with the availability of the Creative Inquiry program to provide support and real project ideas. Open collaboration is a powerful and effective way to cover large numbers of disparate topics related to app development and Creative Inquiry is a rich source for real-life projects.

6 STUDENT EVALUATION

This three-credit course has been well received by students. Students may count it as one of two computer science electives and therefore the course must compete for student enrolment with over 15 other elective computer science courses. It consistently attracts between 15 and 18 students each semester, a very good and manageable size for a project course.

Multiple end-of-semester evaluations show that over 85% agree or strongly agree (ASA) that the course added significant value to their resumes and transcripts, over 90% ASA that the open collaboration policy helped them learn the material more easily, and among students who chose a Creative Inquiry project, over 85% ASA that working on an actual research project with a co-mentor and students from other disciplines was a valuable educational experience. Moreover, over 90% would recommend this course to other students and over 85% reported that they were satisfied with the learning that they received.

On the negative side, over 95% felt that the amount of work required by the course was significantly greater than other three credit hour computer sciences courses and over 85% spent on average over 10 hours per week on this one course.

A bit surprisingly, relatively few students (less than 10%) felt that the absence of a textbook hindered their learning of the material. Moreover, over 95% ASA that much of their learning came from discussions with their classmates and over 75% ASA that they were successful in finding answers to technical questions on blog sites.

7 CONCLUSIONS AND FUTURE WORK

Teaching mobile device software development indeed is challenging. The rapidly changing software tools, the amount of material that must be covered, the need of students for database design skills, and the constant search for real-world applications pose significant problems for the instructor of such a class. Traditional lecture by the instructor no longer suffices. New approaches such as open collaboration among students, frequent presentation of coding tips by students, and continuous communication between instructor and students and among students themselves, are necessary in order for student projects to be successful. And support by the university for undergraduate research projects in programs such as Creative Inquiry, both in terms of academic credit as well as monetary support, helps generate the all important research ideas that produce realistic and beneficial app projects.

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Strategies for Harnessing the Collective Intelligence of Cultural Institutions' Communities

Considerations on Supporting Heterogeneous Groups in Content Production Taking the Quality Factor into Consideration

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Abstract: This support paper builds a theoretical model upon which computer platforms for cultural institutions can be based upon. It analyses three landmark models in the Computer Science history that were capable of harnessing the Collective Intelligence present on gravitating communities. Afterwards, conclusions are drawn regarding their effectiveness in leveraging communities. Instructional Scaffolding and Design Thinking are indicated as important strategies to provide the necessary support to heterogeneous groups.

1 INTRODUCTION

Due to the increase in popularity of social media services and strategies across digital and physical landscapes, there is growing expectation and pressure for Cultural Institutions (CIs) to make the transition from static providers of cultural content to flexible facilitators of interaction, participation, and collaboration among their audiences.

In order to meet those expectations e.g. some museums started to incorporate 2.0 philosophies into their venues to make their role more meaningful to their communities. From interactive installations to collective creation and remixes of content, those initiatives represent an effort of museums to bring students, professionals, hobbyists, aficionados, and basically anyone to be part of the making process.

The outcomes of participatory attitudes that see the public as creative agents can be considerably significant. On one hand, CIs profit from the content and knowledge produced by their audiences. On the other hand, the public perceives CIs as compelling spaces where they can express themselves.

One of the challenges in giving the public the chance to express themselves regards the quality of the content they produce using technology. Poor outcomes can be originated not only by the lack of clarity, clear instructions, and support from the part of the museum app, but also individual deficiencies such as limited experience and knowledge from the part of the public. How can CIs support their public in producing high-quality and reliable content with technology?

This position paper examines successful models in the Computer Science (CS) field that were capable of harnessing the Collective Intelligence to produce high-quality outcomes. They are: the open-source model (OSM), collaboration applications (CA), and software platforms (SP).

Those models offer hints of how to think collaborative apps that take advantage of gravitating communities effectively. However, apart from CAs such as Wikipedia, those models are directed at professionals from the CS field, and do not focus on individuals with little or no formal training. Even Wikipedia can be harsh with inexperienced users.

As a solution for attempting to support inexperienced collaborators of CIs, this paper points out to two well-known methodologies, namely Design Thinking (DT) and Instructional Scaffolding, that are capable of facilitating and supporting the production of content by large and heterogeneous groups when integrated in computer applications.

2 THE COLLECTIVE INTELLIGENCE

Due to new communication technologies, individuals collaborate in a diversity of ways never possible before. On the Internet, the Collective Intelligence is manifested not only by single and collaborative works built upon previous knowledge, but also in the human-human and human-computer relationships on the network.

The vision of past about human-computer symbiosis turned out to be to a certain extent revealing. In 1960, Licklider (Licklider, 1960) in his article *Man-Computer Symbiosis* predicts that human brains and computers would be coupled tightly together and that “the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today” (Licklider, 1960).

Man-made networks connect millions of individuals, who consist of different kinds of biological networks themselves. Neural networks of the human brain share similarities with the Internet regarding their structure and functionality. Eguiluz et. al. describe super connected brain regions in neural networks that appear to work as “hubs” facilitating the communications between distant “nodes” or specific and less connected brain areas [see (Eguiluz et al., 2005)]. Those "hubs" operate in a comparable way to search engines in that they do not hold the information, but point to the location to where it is.

Macro and micro resemblances might hold answers why we are so comfortable with computers. This configuration between biology and technology, the “Global Brain”, holds the potential “to become truly transformative in domains from education and industry to government and the arts” (Bernstein et al., 2012).

2.1 Landmark Models

The *Global Brain* and its collective intelligence foundations, which are the result of human-computer symbioses, can be better examined by looking at landmark developments of the computer history such as the OSM, CA, and SP architectures.

2.1.1 The Open-source Development Model

Open-source is perhaps one of the most well known examples of collaborative work that uses collective intelligence to produce high quality outcomes. Its development model is focused on both the premise of users being considered as co-developers and free-license agreements.

Open-source projects are probably ideal examples of almost non-hierarchical collaborative production processes that are able to cope with highly complicated and large amount of data. As Weber (Weber, 2000) shows, those collaborative processes raise questions regarding motivation of contributors, coordination of projects, and complexity of communities.

In most cases, the OSM does not work on the premise of monetary rewards, but appeals to people’s individual motivations, such as having fun with programming puzzles, contributing to projects that are socially relevant, gaining visibility regarding programming skills, and profiting from more experienced individuals [see (Weber, 2000)].

The Internet stands as a facilitating tool able to deal with large numbers of collaborators. On one hand, the virtual space the Internet provides is capable to scale in a way that physical spaces are not. Almost “unlimited” space can be allocated for communication, data storage, working branches, and individual and collective profiles. The stored data can be picked up and worked further at anytime, anywhere. Therefore, having enough space for specific code branches is important to differentiate and keep projects organized. On the other hand, intelligent algorithms created for e.g. revision control aid programmers to keep track of changes on the code, and help to identify individuals responsible for those modifications.

The distributed configuration of open source projects presents challenges regarding management and control of the work produced. Solving conflicts within groups is also a concern that should be taken into consideration. In the case of Linux, Linus Torvalds is seen as an authority in that he was the founder of the Linux Kernel project. In this sense, Torvalds and programmers who are high in the hierarchy have the last word in decisons. Apart from that, and in most cases, the code decides.

2.1.2 Software Platforms

In Product and System Design, a platform is a structuring foundation on top of which a set of independent elements and interfaces can be arranged, rearranged, and innovated upon [see (Griffiths, 2010)]. Shared key components and assets define the core of the platform and diversification can be achieved by building upon and extending capabilities to build new, but related foundations. Baldwin et. al. (Baldwin and Woodard, 2009) point out that most platform definitions identify the reuse or sharing of common elements as core characteristics, and that all platforms are “modularizations of complex systems in which certain components (the platform itself) remain stable, while others (the complements) are encouraged to vary in cross-section or over time“ (Baldwin and Woodard, 2009). Well-structured platforms allow numerous advantages, such as cost saving, increased production efficiency, ability to evolve and produce variety in large scale.

In CS, this term was initially used to define the computing hardware and later on the operating system (OS) upon which programs would run. Earlier computers had to be built from the ground up always when new releases were planned. Not infrequently, because of incompatibility with newer systems, there was a costly process involved in moving data to different formats.

As computer hardware was becoming modular and increasing its complexity, systems without OSs presented enormous challenges. Earlier computers required the full hardware specification to be attached to the application every time it ran. Therefore, a program not only would be suitable for just one machine, but also it had to be loaded every time someone needed the program. As a way to optimize computers, the industry realized that some fundamental set of instructions could be loaded into the memory and managed separately. The distinction between applications and OS was then created.

The reuse of code and the modularization of computer systems brought many advantages to the field especially regarding cost, manageability, and evolution of complex systems. According to Baldwin et. al., “by promoting the reuse of core components, such partitioning can reduce the cost of variety and innovation at the system level. The whole system does not have to be invented or rebuilt from scratch to generate a new product, accommodate heterogeneous tastes, or respond to change in the external environment“ (Baldwin and Woodard, 2009).

The modularity of computer systems became even more robust with the advent of Object-Oriented Programming (OOP) that took the reusability of software components to a next level. Powerful software development frameworks reduced the complexity and cost of writing code. Frameworks “mean a real breakthrough in software reusability: not only single building blocks but whole software (sub-)systems including their design can be reused.”(Pree, n.d.)

The inexpensive and powerful strategies allowed by frameworks create a rich ecosystem for application development that lead to an enormous variety and innovation, especially when it is popular and open to a great number of developers.

2.1.3 Collaborative System Model

Collaborative systems are designed to support individuals to accomplish tasks in a cooperative manner. The free-content encyclopedia Wikipedia is a successful example of a tool based on an openly editable model that came from the open source experience, which sees users as contributors. Wikipedia covers an enormous amount of subjects. More than 22,000,000 articles were written so far. As in open source software projects, the outcome of the collaborative process lead to the creation of articles “of remarkably high quality“ (Malone et al., 2010, p. 21).

Originally, Wikipedia was proposed as a complementary project for its predecessor Nupedia as a mean to generate faster and larger amounts of content. Although also thought to be collaborative, Nupedia was not able to release consistent amount of articles during its existence. The main problems Nupedia had were its highly bureaucratic publication procedure, elitist selection of contributors, and non-wiki platform. Nupedia’s content approval process had seven complicated steps. Non-expert individuals willing to contribute would most likely be vetted with only few cases of exception.

Therefore, Jimmy Wales and Larry Sanger decided to run Wikipedia to facilitate the productions of articles that later would go for the Nupedia’s reviewing process. Basically, the idea was to find a way that uncredentialed people could participate more easily. The differential of Wikipedia relied on its deep open-source philosophies, which considers everything as a “draft in progress, open to revision” (Rettberg, 2005). Impressively, the quality of the articles and the fact the Wikipedia is not prone to amateurism and vandalism is due to the community that is “passionate about the topics they know and care about”(Rettberg, 2005).

The wiki architecture is key to the success of Wikipedia. Anyone is able to contribute including anonymous users. Wikipedia allows contributors to publish their unfinished drafts, so others can make improvements on them. However, the decision of either accepting or not unfinished contributions depends on the patrol division which checks new articles shortly after they are created. Sometimes arbitrary decisions can be made and contributors should engage in discussions to clarify uncertainties. This process can be very localized and specific to the people in charge of approval. In any case, individuals are driven to cooperate if not with writing new publications, then with linking keywords among articles, fixing spelling mistakes, or improving clarity of sentences.

Nothing else holds Wikipedia from being just a wiki than its policies and guidelines. The content created is free for others to read and modify. This is a strong motivation for people to work in something they believe to be valuable for the good of the society. However, Wikipedia has a different culture from regular wikis, because "it's pretty singlemindedly aimed at creating an encyclopedia." (Sanger, n.d.). Although the architecture of wiki software encourages openness and de-centralization allowing deviant content being fed into the system, the community of wikipedians is compliant with the Wikipedia's five fundamental pillars [see ("Wikipedia:Five pillars - Wikipedia, the free encyclopedia," n.d.)].

2.2 The Building Blocks for Quality

What are the building blocks from those models that can be applied to the design of systems capable of harnessing communities' collective intelligence to generate new content with acceptable quality?

In the case of the OSM and CA, the community is the force behind their success, because they see users as co-developers and as part of the decisions. In the case of the open-source, the easy access to the code along with the licenses is one of the most important aspects. Each member of the community has unique needs that are met without them having to reinvent the wheel. This is a direct benefit. At the same time, new extensions, adaptations, and improvements automatically appear in the process. In the open-source movement, the product comes from improving and building on other people's knowledge. And because there is no clear hierarchical authority, in most cases, the quality of the code decides whether it will be popular.

Other motivational aspects are important in leveraging the community. Individual motivations such as contributing with projects that are fun, challenging, educationally beneficial, socially relevant, and can improve one's reputation play a big role in the community. As for the Wikipedia, however, the natural selection that takes place in the case of open-source projects does not happen in the same way. That is because not only the goal of this model is different, but also Wikipedia is more centralized and hierarchically structured. Wikipedia architecture does invite users to create new articles and modify existing ones, and doing so is easy to the extent of not needing to create a user account on the website in order to contribute. The facilitated process of contribution generates an enormous quantity of new content.

Differently from code, that needs to be logically coherent in order to compile, textual information is subtle in hiding factual inaccuracies and non-neutral point of views. Besides having good structure and style, Wikipedia articles need to gather support from other textual information, which takes the form of references, working in a similar way as in academic texts. In order to check for inconsistencies and errors, Wikipedia relies deeply in few contributors, such as the administrators and patrollers. Because of its textual, localized, and more hierarchical structure, it allows certain contradictions inside the system. Although Wikipedia accepts contributions from anonymous users, it is up to the patroller e.g. to accept or not to engage in a discussion about an article that is about to be deleted depending on whether or not the contributor has a user account. Another example is that a contributor would be willing to start a topic with a small contribution and expect others to build on that. But once again, the patroller can expect that a certain threshold to be crossed regarding the amount of text in the article, no matter if Wikipedia in fact incentives small contributions. In any case, although frustrating for newbies, the Wikipedia process is able to generate high-quality content that comes primarily from the large amount content being produced everyday together with its hierarchical selection.

In the case of SPs, its power is in its modularized structure, stable layer of components, and the possibility of numerous configurations provided by a set of compatible and independent elements. The quality factor from platforms comes from the easy and inexpensive experimentations that can be produced. In all three examples, quantity seems to be a determinative factor for quality. One of the cores of the OSM is the fact that it is also based on SPs and modularization is one of the aspects that allow the reuse of code, which leads to cheap and countless forked versions of software.

3 SCAFFOLDING AND DESIGN THINKING

When thinking about harnessing the collective intelligence of the public of CIs for producing content, one should be careful to be as inclusive as possible regarding the public. The three models presented above offer many hints of how to leverage the crowd. One of the most important of them is undoubtedly seeing the members of the community as active co-creators. But the primary focus of those models is on the production of digital content. Supporting and educating users is something that can or not come along during the production process in those models. Acquiring skills to write computer programs or articles is usually seen as pre-requirement in order to be a respected contributor of those movements. CIs, on the other hand, have as one of their primary focus educating their public. Therefore, educating while producing content is a desirable configuration for CIs.

The OSM is perhaps the model that offers the most extensive support for its users. The GNU project defines open-source software as a matter of individual liberty and a right for the user "to run, copy, distribute, study, change and improve the software" ("The GNU Operating System," n.d.). In this sense, educational aspects are considered when talking into account that the user has the right to analyze and study how a program works and how the code should be written. The community plays also an important role regarding educating new generations of programmers in that there is a lot of knowledge exchange in forums.

Open-source software usually goes along with a strong community that provides extensive support. In addition to that, because open-source is highly decentralized, the need for consensus is not a constant issue, as in the case of Wikipedia. That means that the OSM gives more space for individual contributions. That allows small groups of people with the same interests to take further the development of specific code that might not be of interest to a large community.

The wiki architecture, on the other hand, searches for consensus and does not give space for beta versions of articles, what might be a good strategy for supporting beginners. The higher the degree of modularity, the easier it is for contributing. This strategy is deeply used in programming languages and SPs, but no good solution was thought yet regarding text. The history strategy used on Wiki articles fragments information by tracking changes and creating small chunks containing the modifications. Nevertheless the larger the article, the more difficult it is to manage those changes.

In order to make the creation of content highly inclusive, it is not only necessary to modularize and give space to advanced users and beginners, but also to ensure that they get proper support. Moreover, the community should also be open with dealing with poor contributions not by prompting them for exclusion, but driving the contributors towards refinement. Instructional scaffolding therefore is a good strategy in this regard.

The concept of scaffolding was introduced by Wood, Bruner, and Ross [see (Wood et al., 1976)] but derives from the socio-constructivist theories of Vygotsky on the "zone of proximal development". Scaffolding is the assistance provided by experienced individuals that enable inexperienced ones to succeed in tasks that otherwise would be too difficult. Nowadays, this concept has been changed and adapted taking into account computer-based learning environments. Some scaffolding strategies are automatically integrated in software, making it unnecessary e.g. the presence of human assistance. Those strategies can including measures that "induce and stimulate cognitive, metacognitive, motivational, and/or cooperative activities during learning" (Raes et al., 2012). Scaffolding can also support ways for individuals to keep track of overall plans and progress, which are common obstacles faced in tasks that require learning. One way of doing so is automatically handling nonsalient and routine tasks, reducing the cognitive load while executing a task. This allows learners to focus only on what is important.

As for CIs, Nina Simon (Simon, 2010) talks about the importance of instructional scaffolding when museums ask visitors to create content. One of the problems, is that "open-ended self-expression requires self-directed creativity" (Simon, 2010). That can be difficult especially for would-be participants since it leads to the situation where "participants have to have an idea of what they'd like to say or make, and then they have to produce it in a way that satisfies their standards of quality" (Simon, 2010). By directing, scaffolding limits the participation, but allows visitors to feel more confident and confortable in engaging with CIs.

While instructional scaffolding is able to provide necessary support, DT principles can be used to drive individuals to advance their knowledge in creative ways. As Welsh et. al. (Welsh and Dehler, 2012) point out, "design thinking's emphasis is on developing possibilities rather than satisfying constraints" (Welsh and Dehler, 2012). DT counts on abilities such as intuition, pattern recognition, and generation of ideas that are emotionally meaningful. Furthermore, it eliminates the fear of failure, because it is experimental and non-judgmental. It is human-centered, meaning that it considers the point of view of the community. It stimulates great amount of input that is allowed by thinking *out of the box*. In the context of CIs those features are desirable, because they are inclusive, especially when taking children into account. The most important contributions of DT in the context of CIs are methods for defining important issues through empathy and gathering insights in a non-critical way, that can be later explored.

It can be hard to conciliate a methodology bounded for innovation and experimentation with instructional scaffolding that tries to limit open-ended possibilities. Notwithstanding the contradictions, DT can be seen in fact as a scaffolding strategy for leading contributors towards specific goals. And, because of its flexible nature, it can be adapted to particular contexts regarding its phases, and methods. From more strict approach, when dealing to historical facts, to more associative thinking, when trying to interpret an abstract painting, those two methodologies combined hold the potential to help the crowd to make sense and produce original content based on their own interpretation and research.

4 CONCLUSIONS

Contributing to the construction of knowledge, and being inclusive and innovative concerning the outcomes produced by the public of CIs is no easy task. Creating content for CIs means dealing with open-ended possibilities, heterogeneous groups, and require significant disciplinary knowledge and metacognitive skills. Those requirements are not always met. In this sense, technology appears not only as an instrument for inclusion, but also as a facilitating tool to accomplish tasks.

In the CS field, the OSM, CAs, and SPs are three landmark models for harnessing the collective intelligence of gravitating communities to produce reliable and high-quality outcomes. Some of their most important features are:

- Dealing openly and fairly with the community they serve to.
- Individuals are seen as co-creators and have their say regarding the direction and shape of most open-source projects and CAs.
- Free access to the core is seen as a right concerning open-source philosophies. This is guaranteed by comprehensive licenses.
- Building on other people’s knowledge is supported by free access to code, text, and structures those models offer.
- Modularization is a key factor for producing derivations, because it reduces costs by promoting reuse of elements.
- The capability of producing great amount of outcomes lead to increase quality.

Those models however are focused on the production of digital content. Support and education of users are in many cases not considered. CIs, on the other hand, have as one of their primary goals informing and educating their public. Therefore, it is a desirable configuration to include sense making and knowledge building into the design of platforms for CIs. Instructional scaffolding and DT offer valuable hints in this regard. They are able to organize the creative process, directing it towards innovation and experimentation by providing the necessary building blocks in the same way platforms do. Scaffolding promotes focus. DT offers human-centered strategies for empathy, need finding, and generation of insights in a non-critical way.

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How Youth Construct Learning Trajectories in the Digital Age?

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Keywords: Youth, Digital Learning, Learning Trajectories.

Abstract: People living with decentralization of knowledge and high connectivity. Digital media has changed how we learn and the settings in which learning occurs. Nowadays, we have the opportunity to experience many different experiences through the media and social networks, especially youngers. Although formal spaces are still the main reference for the learning process, the relevance of non-formal and informal spaces cannot be ignored, as well as the amount of learning that is being learned and the nature of this learning. This paper presents an ongoing research which will seek to understand how young people recognize and construct their learning trajectories through digital spaces and what metrics are valid to outline how knowledge moves between these spaces. The research method is qualitative in nature and will be supported in longitudinal studies, which will be the basis for interpreting models capable of representing such paths.

1 INTRODUCTION

The education model as we know it has been facing the great challenge of developing new skills so that young people may be able to establish a new relationship with knowledge, increasingly affected by the pace of change and the pervasive use of technology. Being able to continually update what we know and what we can do, will be something essential in the future. To ensure the arc of lifelong learning it is necessary to revisit the concept of learning.

The type of learning that will define the 21st century is not only associated with the knowledge we acquire but also with the contexts of learning, due to the necessity to better understand in which settings learning has occurred. Contexts allow people to develop a meaning for things, understand the relationship between school content and the world as well as engage with the learning process. In this scenario, the use of technology has been responsible for the construction of a new culture. In digital world, people learn to observe and experiment, learn what they are willing to learn, are guided by their passions and recognize the collective as an important resource to the process of producing new knowledge (Thomas and Brown, 2011). People take greater control of their learning process alone when they are motivated by interests and when they have the resources needed to enable them achieve their goals. The existence of these conditions provides an environment so that they can develop their intelligence (Gee, 2013).

The digital era has been marked by decentralization of knowledge and high connectivity. Technology has changed the equation of what it is learned, how we learn it and the settings in which it occurs. Young people end up engaging in a special way with different kinds of learning through participation in communities of practice, social networks, the use of games and other media. Thus, although the school is still the main reference of the learning process, the relevance of these other areas cannot be ignored, as well as the nature of what young people are learning. In digital spaces young people are free to imagine, create and take part in flow experiences which put them in contact with states of frustration and epiphany, important factors for engagement and self-regulation.

Trying to understand what learning represents in these new spaces, what is its nature and how it manifests itself, many scholars have been trying to understand the principles behind the process of learning in the digital age as well as the cultural and behavioral aspects that emerge from this intense interaction of young people with technology. Ethnographic studies of M. Ito, set in the universe of social networks, suggest genres of participation. At first, young people seek to discover the meaning of being with other people, later on they try to understand the environment they are using, and finally they experience how to use the resources that the environment provides so that the process of exploitation gets deeper (Ito, 2010). Young people's practices and behaviors in this new culture show that they are able to develop multiple identities from different domains, especially when they are in situations that allow them to exploit opportunities and deal productively with failure. Similar to the attitude of a scientist before the failure of a hypothesis, it is essential that the learner has available space for experimentation and hypothesis testing with a chance to receive feedback on the spot, and, thereafter, she may reflect, share, create, rework and retest. And in this kind of knowledge production that Seely Brown calls tinkering, the learner is able to develop multiple identities in the spirit of "I am what I create".

When young people use technology, they take control of what they learn and develop a natural process to progress in this way. This reflects a process of paradigm break, in which the idea that learning occurs predominantly in pre-defined space and time is being replaced by another one, which recognizes the existence of a fluid process that occurs in multiple places, times and circumstances which invite people to explore, learn and develop yourself. The diversity of digital spaces constitutes a network capable of enhancing the intellectual development of people and a complement to formal education. Although many things about culture, practices and behaviors of young people in the world of technology are being unveiled, we still know a little about how young people create learning cycles and routes between spaces mediated by technology.

In this research, we try to understand how young people construct their learning paths from the digital spaces they use and which metrics are valid to outline how knowledge moves between these settings. Studies of this kind are complex, especially because they require the researcher is immersed in the culture and daily life of the research subjects. This article presents the objectives of a program of research that has been initiated in Brazil, as well as its methodological design. As outcome we hope to create a narrative that shows how young people construct their learning trajectories, in which it is possible to identify the main stimuli that cause some young people follow some paths (and discard others) remain engaged and develop different degrees of reasoning skills and cognition to achieve their goals. We also intend to identify elements that can be used to measure how knowledge moves from an area of learning to another and to help young people to recognize their trajectories.

The paper is organized as follows: Section 2 presents the theoretical background underlying the research. Then, Section 3 presents related works and the research questions that will be addressed in the study. Section 4 presents the research methodology that will be used. Finally, Section 5 discusses the relevance of this study.

2 CONCEPTUAL BACKGROUND

The 21st century is marked by the influence of technology in the educational field so that the learning theories have been revisited. Most theories were developed in a time when knowledge production was slower and when people did not live with such high connectivity. Learning was not considered as a process that took place out of people.

But according to Siemens (2004), the creator of Connectivism, a learning theory for the digital age, learning is a continuous process that takes place in different spaces and it is governed by the divergence of views, the ability to create connections between several sources of knowledge and where the ability to access new information is more important than the current stock of knowledge. In this theory, learning is the process of creating networks, where nodes can be people (experts, teachers, classmates and communities), but also the technology itself. Here, the role of the educator is to create learning ecologies, form communities and leave students free to explore this environment.

Converging with this idea, new methodological concepts have been shifted from the use of technology as a way to reduce the costs of delivering content to another one which aims to establish a network of connections between knowledge, context, people and different types of media, making this network work as an enhancer feature and also as a facilitator of *situated learning* - which is that one which occurs when someone is able to understand the concept and establish meanings to it (Gee, 2010) - and *deep learning*, that represents a state in which the student is motivated to exert the necessary effort to learn (Schunk et al., 2008).

The holistic view of Connectivism converges with values and principles of Connected Learning from Ito et al. (2013), which emphasizes the design of learning ecologies as part of the instructional design. The Connected Learning approach recognizes the power of technology to scale, diversify, increase engagement and expand the range of learning experiences.

Realizing the importance of networking in the construction of the learning process, it is also recognized that there are different spaces where learning can rise up. The horizontality of knowledge shall then be cut by experiences that arise within and outside the school and allow the transit of learning through the different areas young people occupy, whether physical spaces - such as school, community, church, or family - or virtual ones - like social networks, blogs, *YouTube* and games. This transversality has been kept in social relationships, academic orientation and communication infrastructure that turns learning into something connected to the real world.

People are increasingly learning in different settings. What we learn manifests itself through formal spaces which follow a rigid curriculum, the school for instance; through non-formal spaces where, although there is the structure, there is no obligation to follow a curriculum structure, being considered then temporary environments and situations, such as those related to dance, theater and sport. Finally, through informal spaces that represent contexts in which people engage by choice, in their own time and pace. In these contexts the learners make the schedule and decides the strategies they will use to learn. They are in control of the process.

Several virtual spaces have been presented as powerful learning environments. This tends to be the case of videogames. Squire (2006) has conducted investigations in this direction by studying the universe of games as learning spaces as well as Gee (2010) who studied the potential of the world of videogames for literacy and *situated learning*. Steinkuehler (2006) studied cognition and the universe of multiplayer games and more recently she has been conducting studies in programs outside the school that show that skills such as interpretation, synthesis and power of argument have emerged from the contact of young people with the media (Steinkuehler et al., 2012).

It has been clear that young people are going to build learning trajectories by using multiple spaces. In the educational context, learning trajectories characterize the actions and the reflection process of a person over a period of time. In this research, we take the concept of learning trajectories defined by Erstad et al. (2013), which refers to the ways a person goes through different situations over time. For us, exploitation of these situations which are motivated and established by the use of technology and media can initiate the development of competencies useful for discovering of new knowledge.

3 RELATED WORK

The discovery of learning paths is an area of research that has been explored for quite some time. The area of mathematics, for instance, has been able to study sequences of activities and stimuli that are effective for guiding children through their levels of thinking and skills. The researches in this area have guided the conduct of teachers and the reformulation of pedagogical practices (Simon, 1995) (Simon et al., 2010).

Nevertheless, in the case of technology usage, young people have control over what they learn and how they learn because they are free to make choices based on what looks interesting to them. Unlike formal education, which can have more control over the development of such trajectories, it's a reverse path when this construction occurs in the digital world. We do not define the paths that the young people will take. They do. And, what do we know about the connections that are established when young people use media? How do the knowledge and skills that have been developed move between spaces that constitute young people's daily lives? How do they perceive their learning process stood before the power of technology? How do these experiences affect their learning in formal education environments?

Some studies have been conducted in the attempt to understand this dynamic. The studies of the research group Connected Learning have concentrated on non-formal learning spaces, although one of its observations have lately turned to the experimental school Quest to Learn (Salen et al., 2011). Six case studies have been reported in recent years and they have demonstrated the application of the principles of Connected Learning approach to learning spaces such as libraries, communities of practice and programs aimed at integrating young people with industry professionals (Connected Learning n.d.).

The group has been able to investigate daily practices that constitute the biggest stories arising from online contexts. However, Ito et al. (2013) emphasize that there are few studies that investigate in a systemic way how the knowledge transfer between formal education and other contexts that connect people's lives occurs. As well as the National Research Council (cited in Ito et al., 2013) highlight, when it refers to the lack of studies of systematic nature of these forms of learning mediated by technology and the requirements that have been put for learning to occur.

There is a great interest in exploring and analyzing other types of learning beyond that one which occurs mainly in schools because learning does not end when young people leave the school space. On the contrary, learning is extended and encouraged when they make massive use of technology to establish a relationship with the world they live in.

In order to understand the concept of learning in the 21st century it will be necessary to dive into young people's daily life, their attitudes and into the new meanings that have been created. As Eickelmann et al. (2013) said, it is necessary to develop new conceptions of learning, considering the different locations and contexts involved in this process. Erstad et al. (2013), in turn, also claim that the biggest challenge we have today is finding ways to interpret the interconnections between the different worlds that young people experience in their daily lives. In the studies they have been conducting with the Learning Lives approach, the author and his colleagues have tried to illustrate some circumstances that exemplify the existence of connections and boundaries between young people's practice and the skills they transfer between spaces. Sefton-Green (2013) also reinforces that we know very little about how young people can circulate through informal experiences as well as those that happen at home or at school.

Thus, in the attempt to contribute with the research on learning in the digital age, the research that has been conducted intends to address the following research questions:

Research question 1: How do young people establish their learning trajectories when using digital spaces?

Research question 2: What measures can be used to model the way in which knowledge moves between the spaces?

4 RESEARCH METODOLOGY

In order to identify attitudes, experiences and meanings, the method of this research is qualitative in nature. Thus, we assumed an interpretive epistemological position In the belief that reality is socially constructed, we assumed that knowledge can only be understood from the point of view of individuals who are directly involved with the study of the phenomenon of interest.

4.1 Research Design

The case study will be used as a methodological approach of investigation in this paper to offer a deeper understanding of how and why certain phenomena occur. A case study with multiple cases will be used. In this research, the researchers will accompany young Brazilians who are attending high school and who have a daily intense contact with media and technologies. The investigation will examine the daily lives of individuals when they are in their learning spaces to understand the phenomenon of interest. Besides, it has the intention of creating models that reproduce learning pathways constructed by the subjects.

Since it is intended to identify patterns, ideas or hypotheses to support the existing knowledge base, the case study is exploratory. The study will be conducted in a longitudinal way so that it will be possible to analyze changes during the process of data interpretation. The longitudinal design allows the subject to be investigated several times. Thus, the data can provide greater accuracy in the analyses which are related to changes that may occur over time.

One of the used techniques of data collection has an observational nature. Questionnaires and interviews will also be conducted, as well as ethnographic methods. The research subjects will be followed throughout the year. The process of analyzing the information will happen through an iterative cycle that alternates data collection and interpretation. Several criteria will be used to select the sample of subjects, which adds value to the process of capturing meanings of the phenomenon that has been studied.

4.2 Analysis and Synthesis of Data

In order to properly deal with the wealth of information that will be collected, we will use techniques from Grounded Theory as a means to accomplish the analysis and synthesis of data. The Grounded Theory is a suitable research method to identify a recurring pattern of behavior in the subjects of the research (Glaser, 1998). Thus this method requires the researcher to let go of preconceived ideas so that the focus is kept on the construction of a theory and not in explaining other existing ones.

However, in this ongoing work the researchers have a base of theoretical assumptions (which were mentioned in Section 2) as well as in hypotheses (presented in Table 1). Nevertheless, even if our objective of is the understanding of a particular case, the use of Grounded Theory techniques is justified by the interest in systematizing the process of data analysis and, before the exploration potential of the method, it is possible that in the end of the research a narrative is constructed (as a "local theory") capable of adding value to researches in this area.

Table 1: Research hypotheses.

Hypothesis 1: The situated learning occurs with the existence of learning trajectories.
Hypothesis 2: When a process of knowledge transference between learning spaces happens, the deep learning is taking shape.
Hypothesis 3: Young people are able to recognize what they are learning and when they are transferring knowledge from one space to another.

Triangulation is one of the strategies that will be used to enhance the internal validity of the study. Triangulation schemes of multiple methods and multiple sources will be adopted.

5 RELEVANCE OF THE RESEARCH

The ability of young people to collaborate, to see the technology as a resource to create meanings for educational content and to develop skills so that they may be able to solve problems, has motivated researchers to understand the dimension of the concept of learning in this century.

In order to understand the digital culture and young people's practices, we need a strong immersion in their context so that we can understand how the processes, experiences and decision making are experienced and understood also in informal learning environments. There are still not much published research about new ways of learning which consider ecological and connected approach. Furthermore, the replication of studies in multiple cultural, social and economic scenarios will strengthen the knowledge base in this field. Such studies conducted in countries like Brazil may provide important findings.

In the global scenario, this study will be important to increase the body of knowledge on the pathways, decisions, skills and attitudes that young people take when they are engaged in the learning process. The research aims to identify evidences which show how young people perceive their own learning and how they transfer it between the spaces. This student-focused measurement strategy also shows to be a promising method in the field of assessment of learning. The identification of patterns and the perception of attitudes and meanings will also be important to understand the relationship between learning contexts elements.

Regarding the Brazilian scenario, the use of technology in education is still very much driven by the instrumental view or how to build something that can make the learning process funnier, which is configured in a superficial strategy almost always doomed to failure. Most teachers who adopt the technology do it sporadically through limited and distant forms that allow the students' understanding as well as specific practices of everyday life and school activities (Junqueira 2009). As Bonilla (2012: 77) has pointed out, despite the presence of technology in schools, there is no strengthening of digital culture, as it requires a strong immersion in context so that processes, experiences and decision making are widely experienced and understood, making sense of the practices, either social or pedagogical ones.

Thus, it is perceived that there is to some extent a state of disregard. Whereas in Brazil technology has been present in schools for almost 30 years, it is necessary to advance research in this field, mainly because it may be possible to see through quantitative research that young people consume technology outside the school in a very different way than it occurs within school. However, more investment needs to be made in qualitative research that can influence education policies which value the intellectual potential of young Brazilians. After completing the literature review, the research is at the stage when the first instruments of data collection are planned as well as the selection of samples of the participants.

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A Computer-based Educational Adventure Challenging Children to Interact with the Natural Environment Through Physical Exploration and Experimentation

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Keywords: ADHD, Australia, Autism, Biodiversity, Biotope, Computer based Learning, Computer in Education, e-Learning, Environmental Learning, Environmental Education, Game based Learning, Game Design, ICT, Internet, Interface Design, Motor Activity, Mobile Computing in Education, Outdoor Education, Primary School Education, Queensland, Situated Learning, Video Games, Young People and the Environment.

Abstract: The researchers' paper discusses the development of a computer-based educational game which challenges children to interact with the natural environment through physical exploration and experimentation. The researchers' project seeks to counteract the negative behaviours associated with excessive computer game play amongst children 8 to 12 years old. By leveraging the positive learning outcomes that can be achieved through computer gaming and combining these with outdoor learning strategies, *Jumping the Fence* encourages children to take responsibility for surveying and caring for a local ecosystem. The game requires children to reflect critically on their computer use, become more physically active, gain social skills and develop an affinity towards nature. Educators are able to adapt the game to their school's own curriculum and thereby provide an alternative learning strategy that encourages physical and social engagement.

1 INTRODUCTION

The potential benefits of computer games in education, training and entertainment are widely appreciated, but their downside is also equally a matter of concern. Whilst computer games are mostly played for recreational purposes, or to keep the player in suspense, the frequency of game playing and the average duration of the games we now engage in often bring about unintended consequences. On the other hand, not everything about playing computer games is bad. Computer Based Learning (CBL) has great promise as an instructional tool and, whether we like it or not, proficiency with computers has become a key part of the skill set required by modern children, and familiarity with interactive technologies is essential for success in contemporary society.

The question that concerned the researchers was: how can we balance the benefits of CBL and computer literacy with the disadvantages of spending large amounts of time in front of a computer? Would it be possible to design a computer based learning game that actually required students to get up from their seats and move around in their nearby environment in order to engage with and advance in the game? In order to answer to these questions, the idea of creating an educational game called *Jumping the Fence* (*JTF*) was born. The game has been proven to be successful in providing alternative learning strategies that encouraged students in physical and social engagement.

The paper covers the methodology, the design and construction of the game, the observations made during the testing phases and end with a discussion on the outcomes of the research project and by finally providing some suggestions for future research.

2 LITERATURE REVIEW

The literature review revealed quite early in the study that computer based simulations mirroring real life examples combined with a good narrative are known to be highly effective in developing an understanding of complex systems (Wastiau, Kearney and Van den Berghe, 2010; Barab, 2009;

De Freitas and Neumann, 2009; Royle, 2009; Salen and Zimmerman, 2004; Dziorny, 2003; Garris, 2002; Klaila, 2001; Prensky, 2001). It also became clear that such strategies could be readily applied to developing real time educationally focused games that address complex environmental and scientific issues and that outdoor learning was a tried and tested educational strategy well suited to support this area of learning (Young et al., 2012; Knoll, 2011; Nichol et al., 2007; Cooper, 2006; Dillon et al., 2005; Leger, 2003; Lund, 2002; Neill, 2002; Fjortoft, 2000; Lappin, 2000; Moore and Wong, 1997). For these reasons, the study was designed to find out whether or not the idea behind the *Jumping the Fence* educational game would work in practice and whether the gaming and learning strategies developed might be refined for further use in other areas of education. Furthermore, it became apparent that if such an idea was successful, such a game might encourage users to reflect critically on their daily computer use and provide educators with a healthy educational alternative to the current classroom based approach to computer based learning activities. The questions arising from the literature review resulted in the formulation of the following two guiding questions:

- Can a computer based educational game be developed that encourages young people to physically interact with the natural environment?
- What interpersonal strategies might be identified that would help achieve these outcomes?

3 METHODOLOGY

The *Jumping the Fence* project utilises design-based research as its primary methodology, since this approach allows for the carrying out of both design and testing in the context of real-life settings (Barab et. al 2005 p.91). Although normally considered to be a methodology primarily associated with educational practice, the iterative nature of design-based educational research aligns directly with the working methods used extensively in both creative arts practice and throughout the design professions. The use of an educational, design-based research methodology allowed the author to create an initial application which could then be used as a test vehicle, from which outcomes could be used to improve the application in an iterative process—as is typically done in most design related research. According to Barab and Squire (2004) "design-based research involves introducing innovations into the booming, buzzing confusion of real-world practice (as opposed to constrained laboratory contexts) and examining the impact of those designs on the learning process" (Barab and Squire 2004 p.4). From such testing the "lessons learned are then cycled back into the next iteration of the design innovation" (Barab, 2005 p.92). This iterative approach to design allows for unexpected or unpredicted events and outcomes identified during test trials to be accommodated into the design process and future outcomes. In this way, the researchers could be open minded to surprises and react appropriately by adjusting the design of the application to cater for the needs of the research subjects and the environment where the test takes place. To gain a better understanding of how teachers and students were responding to the design and functioning of the game, the researcher relied primarily on the gathering and analysis of both quantitative and qualitative data, which in turn determined the evolving technical structure of the game mechanics and game story. Throughout the testing of the game, student and teacher interaction with the game, as well as the learning outcomes were measured by practically assessing the student's acquired knowledge, reactions and experiences in four ways—via oral assessment (interviews with students and staff before and after playing the game); by questionnaires at set intervals during the study; by confidential feedback from teachers based on course assessment and subsequent classroom observations and, lastly, by observation in the field (video recording how students and teachers acted and interacted and documenting a range of associated activities, such as what students observed and wrote about in their field diaries). In particular, teacher and student feedback and interviews later proved to be a valuable source of evidence that clarified many of the activities and interactions that were evident in videotaped field recordings.

4 THE GAME

The aim was the design and production of an alternative form of computer game, which seeks to blend the benefits of computer based educational gaming with a range of strategies that encourage the gamer (and student) to move beyond the restrictions of the computer and the classroom and engage directly with the natural environment—in the process forming research groups, developing social skills and taking part in a range of low-impact, outdoor physical activities. In the playing of the game, it is hoped that the student gamers will learn about Australian native wildlife, science, the environment and sustainability issues and—above all— they might have fun in the process. The practical development of the first trial version of the *Jumping the Fence* game was based on a preliminary study designed to identify a suitable area of study to which the researcher's project and ideas could be applied and tested. It was decided to structure the game and its educational outcomes, its visual design and language, as well as the levels of computer literacy required to play it so as to be relevant to Australian Year 5–7 students engaged in the standard Queensland primary school curriculum. The children in the sample that volunteered to participate in the study were typically between 9 and 12 years of age and were drawn from two composite year classes (grades 5-6 and grades 6-7)—which accounts for the wider than might be expected age range for such a trial. Since the primary aim of the *JTF* game was to encourage students to engage with outdoor learning and physical activities and, in the process develop an understanding of environmental and sustainability issues, as well as knowledge of Australian wildlife, plants and habitat were identified as being most relevant to the author's project. When students were asked about their favourite non computer games, the following topped the list: *Lego*, swimming, dancing, camping, bike riding, cops and robbers (and other chasing games), supervised team sports activities and some board games, in particular *Dungeons and Dragons* and *War Hammer*. Most students were familiar with Chess and some had seen Backgammon, but these were more often played by parents or older relatives. That so many children were familiar with *Dungeons and Dragons* and the concept of role playing games (possibly because the game would have been played by their parents as teenagers and then by them with their children) suggested to the authors that adapting the principles of role playing games might not be as problematical as first thought. Since these games are typically overseen by a Game Master, who controls and delivers the story, the role of the teacher—as guide, administrator, content developer and arbitrator— could also be easily accommodated. In the same way that these games break up their world into a series of grids and tiles, breaking up the *JTF* game in small sections which interact to form a larger picture therefore became an obvious design and playing strategy. Requiring students to accurately measure and survey their outdoor "research" area and turn it into a 2 by 2 meter grid encompassing an area 8 metres by 6 metres then map this area into the computer—along with making a detailed analysis of the plants and animals that live in each square, requires students to apply skills in maths, geometry, drawing, writing and teamwork as well as observational and communication skills. Children must think spatially and learn how to turn their complex three dimensional real world area into a simple two dimensional map that uses colours and legends for representation. At the same time the players are creating the very grid on which the game will be constructed and subsequently played.

The narrative was created to encapsulate as many of the ELs outcomes for the Year 5 and Year 7 Key Learning Areas (SOSE, Science and Health and Physical Education) as possible, with the view to adding and refining them as the project moved forward. The protagonist of the game is a young female kangaroo who goes by the name of Kangi. Kangi is a very up to date kangaroo who spends a lot of her time in the wilderness of Australia, but who often comes into cities and towns to study humans and learn their ways. Kangi has many magical qualities, including the ability to speak to children and use a variety of modern communications tools (without having to pay for them!). Her mission is to explain to students just how vulnerable the Australian natural environment is and help them understand how they can help protect it and her friends (Figure 1). Importantly, Kangi needs the children's help to not only save the local plants and animals, but to provide information for her friends back home, who are missing their relatives and friends.

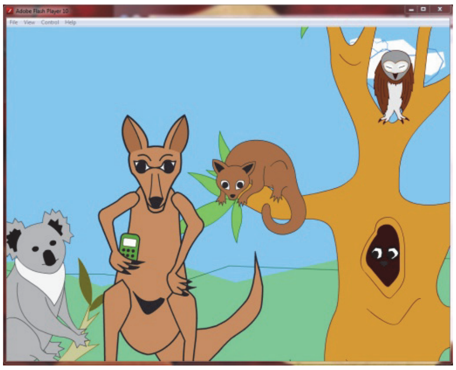

Figure 1: Kangi and her friends explaining how an eco system works.

In summary *JTF*'s model of teaching and learning is a semi-closed circuit model (Figure 2), where the research and learning starts in class by playing the introductory levels of the game on the school workstations. Students can work individually or in their teams at the initial stage, but as students are assigned their roles, each student moves to their own

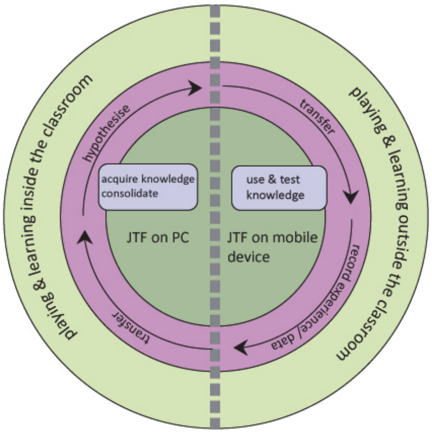

Figure 2: Semi-closed circuit model (indoors>outdoors>indoors...).

computer the focus on the learning tasks associated with their task in the game. Each indoor and outdoor task is assigned by the game master or game system, but input from external sources (student research, new knowledge from guest speakers, the internat.) can also be entered into the system (Figure 3).

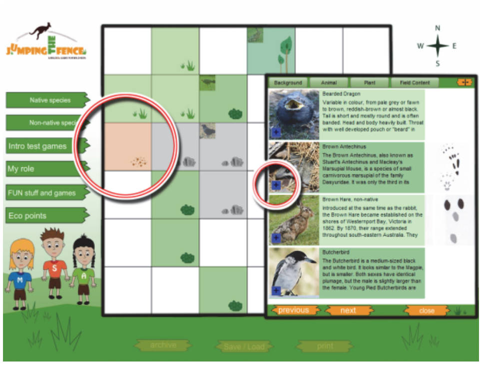

Figure 3: Students placing content into the computer based game interface.

5 TESTING

The testing and development of *JTF* was done with the co-operation of the teachers and students of Sunshine Beach Primary School, on the Sunshine Coast in South East Queensland between October 2008 and July 2010. The first study group consisted of 12 primary school students aged between 8 and 10 years old and the second study group consisted of 25 primary school students of the same age group. Students in both group were identified by the teachers as suffering from Attention Deficit Hyperactivity Disorder (ADHD) but were not identified individually. The first study was divided into two parts. In the first visit, the students were asked to fill in a questionnaire that helped the researchers to build a profile of the students so that the researchers could develop and customise the initial game concept on the basis of the student's preferences and the identified requirements of the teachers and the curriculum. The second part of the study allowed the researcher to test the initial game prototype with the students, gain feedback and make appropriate improvements. The outcomes of the trials were interpreted and discussed with the students and teachers and these revised findings informed subsequent changes to the game prototype. The findings and observations made during this stage of the study are discussed in the first part of this chapter. The purpose of the second study was to test and refine the computer based prototype within the school setting. As before, after each trial the students were asked to fill in a feedback questionnaire and the results were discussed with the students and teachers and then used to further improve the prototype. The findings and observations from both sets of studies were then used to ascertain to what extent the game fulfilled the researchers' initial proposals and research topic.

5.1 Findings of the Game Trials

The results of both test trials suggested that the idea behind the *Jumping the Fence* game is valid and that it is possible to design a computer based learning game that requires students to leave the classroom and spend more time outdoors engaging with the natural environment. It is also relatively easy to encourage students / players to take on the role of active researchers rather than passive observers, given that many are already familiar with role playing games based on their existing experiences of computer games. In taking on their roles, the students clearly developed an understanding of what a biotype is (even though very few of them were aware of most of the correct terminologies) and, in so doing, most developed a sense of responsibility for, and personal connection with, their research areas. Overall, students indicated there was a high level of pleasure associated with playing *JTF*-both parts-the computer based indoor activities and outdoor based non-computer based activities). To the authors, perhaps the two things that came across most strongly from both groups were the enjoyment and pleasure of being outside away from the constraints of the classroom, and the sense of attachment the students clearly developed for the area used in the study. Giving students custodianship and a duty of care for their study area is an important part of the *JTF* game strategy, as it requires the application of physical effort as well as the utilisation of appropriate knowledge. Many children by this age have already developed an appreciation for nature and it is therefore relatively easy to encourage most children to become involved in *JTFs* activities. However, an unexpected outcome of the second study was the number of students (8/24) who specifically identified themselves as not liking being outdoors or who found the experience stressful. Responses such as “I like to stay inside’” “Because outside is nil,” “It is no fun being outside” and “Because I get headaches outside,” were quite unexpected. Although it is perfectly normal for some children to prefer being indoors, it seems that having one third of the students so actively not liking being outdoors is either an aberration or is an indication that changing trends in society may be influencing this outcome. There is a lot of anecdotal evidence suggesting that contemporary children are leading much more protected lives than in the past and those current concerns over “stranger danger” and health and safety issues are bringing about a culture in which children are over protected both at home and at school. It would certainly be unfortunate if this is indeed indicative of a long term trend, although it would be interesting to see whether playing *JTF* over a longer period might change the attitude of some of these students to being outdoors. The students were also very concerned that their biotope would not survive after they left the school (in follow up discussions it seemed to be understood that they would continue to care for the area in their own time after the project was finished) unless arrangements were made to have other students look after it in the future. Several students proposed that responsibility should be passed on to younger students and one student argued that it needed to be someone who could be trusted in the long term, a statement which demonstrates not only how closely the students had become attached to their study area, but an awareness of the longer term needs of the environment they had nurtured. At the 2010 trial, the majority of students thought that it would be advantageous to use mobile devices such as smart phones and tablet computers to play *JTF* and that a mobile device would enhance the game by providing instant access information in the field. Several students suggested that the entire game should be ported to a mobile format for this reason (and also because it meant spending more time outdoors). The students noted that it would be easier to get information directly from the Internet in the course of the game play; but many students argued that mobile devices would not only speed up the game play, they would enable them to stay outdoors all the time. It was quite clear from both written student feedback and follow up discussions that being outdoors and away from the classroom was a major attraction of playing *JTF*. In both field observations and follow up discussions with the teachers it was noted that after only a short time outdoors, the classes were significantly calmer and quieter than they were observed to be when working in the classroom. One teacher later suggested that by the end of the trial it was as if he had different students in the class, since the group as a whole was generally much more collected and better disciplined—in particular the ADHD students, for whom the physical demands of the game proved especially beneficial.

6 LIMITATIONS AND FUTURE RESEARCH

The data and findings described derive from only two small-scale studies, with samples consisting both times of the equivalent of just one class (although students in the first trial were from different class groups and largely did not know each other, as opposed to the second trial where all students were classmates). Nevertheless, the limited number of students will have influenced the validity of the study results to some degree. For this reason, it is suggested that further studies be undertaken with larger sample groups. The benefits associated with outdoor education are well documented in the literature, but observing how *JTF* works in a more urbanised environment would certainly be of great value if the game is to be thoroughly tested for its potential as a vehicle for environmental education.

7 CONCLUSIONS

The findings clearly demonstrate that the *JTF* game supports teaching and learning in both the indoor (mainly computer activity based) and outdoor learning environment. The game also shows that individual and group tasks can be designed that bring team members together to engage in co-operative learning.

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Learning with Strangers
The Value of Sets in Online Learning

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Keywords: Social Media, Education, Learning Technology, Group, Network, Set, Collective, Lifelong Learning, e-Learning.

Abstract: Most research and practice relating to online and distance learning to date has focused on the social form of the intentional *group*, a named collection of people, typically hierarchically organized, with norms and/or explicit rules of conduct as well as inclusion or exclusion, membership, pacing and shared goals. The group provides a backdrop and infrastructure support for formal or informal learning activities. Since the last decade of the 20th century a different social form, the *network*, has been the subject of much research in informal and non-formal learning. Increasingly, however, we teach and we learn with and from countless anonymous others that are not formed into either identifiable networks or groups. We describe a collection of people who share little apart from interests or attributes but that none-the-less affect one another's learning as the *Set*. Under the right conditions, collective intelligence (or *collectives*) can emerge from such sets that can actively guide learning. In this paper we explore the nature of set-based learning and the role that collectives can play in helping or hindering learning.

1 INTRODUCTION

Much learning through the Internet involves following or active engagement with strangers, whether through sharing ideas and comments in blogs and websites, editing a Wikipedia page, contributing to a Q&A forum or posting to a listserv. Traditional notions of social capital, group dynamics and social contracts are significantly mutated when we are not talking with people we know or recognize, and we are in the open, away from the safety of controlled groups of people with shared purposes and norms. Beyond that, there are often emergent and/or designed effects arising from large-scale interactions that play an active role in shaping the behaviours of participants in this partly anonymous crowd. This paper is concerned with the actual and potential value of these sets of minimally connected strangers both purposefully and inadvertently helping one another to learn. As well as explaining how such sets differ from the more commonly researched social forms of groups and networks, we will be listing some of the common set tools, some of the ways they can be used for learning, some of the risks and dangers, and some potential and actual solutions to those problems.

2 GROUPS, NETS, SETS AND COLLECTIVES

2.1 The Group

The bulk of research into social learning, whether at a distance or not, has so far focused on ways that intentionally formed groups can be used to help people to learn. The *group* (or often 'team' in business circles) is a fundamental social form. It plays out in myriad ways, from the most rigid committee or court to the most informal study group or family, but it has some common features. For learning, there are familiar groups such as classes, cohorts, tutorial/seminar/working groups, teams, faculties, schools, houses and clubs. By and large they have leaders and, beyond a certain size, hierarchies of leadership. Almost all have names. All have implicit or explicit rules and rituals that govern how members should behave, how people become members and, as importantly, who to exclude.

In a learning context, most are time-limited, specify distinct goals and operate to a schedule. Groups tend to go through phases of development, such as forming, storming, norming and performing, or Salmon's five stages of e-moderation (Salmon, 2000). Groups have explicit membership: it is almost impossible to unknowingly become a member of a group and it is at least in principle possible to know the names of all the other group members. The overhead needed to organize, schedule and maintain a group is significant. Groups require commitment and do not scale well in a learning context to large numbers of people.

2.2 The Network

Over the past few decades there has been an increasing amount of research into an equally or more important social form for learning, the *network*. Every individual's networks are different from every other's, because networks are constituted of the people we know. From the weakest ties of recognition to the strongest friendships, we are normally members of many overlapping networks, often without even being particularly aware of it. Networks are mostly emergent structures based on the connections we make with others, and their edges are typically fuzzy and constantly shifting. Ideas, norms, behaviours and other forms of learning can and do spread through networks, often with amazing speed and effect. The Internet has played a major role in making networks more tangible, most notably through social networks like Facebook, LinkedIn and Google+. However, many other Internet-based systems from emails to instant messaging to blogs enable the nurturing and growth of social networks. The network is a fundamental social form for learning, described by Wenger as a community of practice (Wenger, 1998), later refined to the notion of the network of practice (Wenger et al., 2011) and providing the basis of Siemens's Connectivist model (Siemens, 2005). Indeed, networks play a crucial role in groups, connecting members within the group as well as sustaining the exchange of knowledge beyond the group.

2.3 The Set

A third important social form can also be described that extends beyond groups and networks, and that has not received anything like as much recognition in literature on learning: the *set*. **Sets are simply collections of people with shared attributes who share the same virtual or physical space.** In a learning context, the most significant shared attribute tends to be a shared interest in a topic but others may matter too, such as prior knowledge or location. In our non-virtual lives we can and do make use of sets to learn. For example, when we publish a book or a web page we normally provide categories (tags) so that people with a particular set of interests or attributes can find it. We do not know who they are but, as authors, we are communicating with and to the set of people who may find it valuable. Equally, the set can communicate with us: for instance, the fact that there is a set of people outside who are carrying umbrellas tells me that I should probably do the same when I go out. More deliberate uses of sets are common: shows of hands in a classroom, divisions of crowds by demographic, gender, or other lines are a regular feature of our lives, for better or worse.

Part of the reason for the lack of recognition of sets for learning till now is due to the fact that, in most social contexts before the advent of the mass Internet, sets performed relatively little useful work. The Internet makes it possible to interact with a vast number of people with whom we have no shared social connection at all. Much of the activity that drives Wikipedia, for instance, is from anonymous people whose only interaction is in editing one another's words. While networks and groups exist on the Wikipedia site and can play a strong role in the development of pages, there are at least as many people contributing to the site who are helping one another without ever being aware (or caring) who is helping whom. Likewise, though networks and groups exist on Q&A sites like Slashdot, Yahoo Answers or StackExchange, much of the learning that results from their use emerges from virtually anonymous interactions between people unknown to one another and not organized into groups or networks. Sets are the basis of Google Search, arguably the most significant learning technology invented in the last millennium. Sets underpin crowd-mining technologies such as Amazon's book recommendations, Netflix's movie recommendations and Pandora's music recommendations. Countless specialist sites cater for particular interests that are, by nature and our definition, set-oriented. Curation sites like Pinterest and Learnist are largely set-oriented, focusing on topics rather than communities. Twitter hashtags are primarily concerned with sets, not networks or groups. Usenet newsgroups and email listservs have long been an important source of knowledge and dialogue, often among strangers sharing nothing but an interest in a topic or need for topic-specific information. Despite the popularity of group-supporting tools like learning management systems and network-nurturing tools like Facebook, Academia.edu and LinkedIn, set-based interactions are the dominant social form in Internet-based independent learning and may soon be in formal education as well.

2.4 The Collective

Set-oriented systems can be wild places, full of half-truths and falsehoods as much as rich and meaningful information, not to mention abusive, malevolent and mischievous contributions. This is overcome in part through reification of the conversation, so that individuals can choose the most compelling solutions and arguments. More significantly, almost all successful systems of this nature incorporate crowd-sourced algorithmically collated metadata like ratings, likes, reputation measurement and filtering tools so that the crowd can collectively guide its own members.

We refer to the outcome of this algorithmic combination as a *collective,* using the term much like the creators of Star Trek's Borg to signify a single entity made up of many independent entities acting as one. Collectives combine the behaviours of many people through one or more algorithms in order to provide help, guidance or structure to otherwise overwhelming or ambiguous content generated by the crowd. The algorithms may be provided by machines, such as in rating systems, or collaborative filters, or by people, such as when people are collectively drawn to active sites or repelled from those that are too active, or both, as we see in people's reactions to the search order of a Google search or the weightings of tags in a tag cloud. In many cases, processing is split between a machine and the heads or hearts of human beings, the machine offering alternatives according to one set of algorithms and people making choices using others. A collective is not a social form as such, but the emergent result of people interacting, directly or indirectly, with one another.

2.5 Set Combinations

Social forms seldom exist in isolation. Sets may be a supplement or a pre- or post-emergent form of traditional group-based learning, existing networks or conventional individual study. Equally, the social forms we describe are not binary categories but are more like primary colours that often occur in blends. For example, at our own Athabasca University, our individualized study model means that students are self-paced, choosing when and how they work over a six-month period. It is thus rare for two students to be working on the same things at the same time. Despite this, forums other social tools are normally provided for each course. Although courses share some group-like features including rules, shared goals and hierarchies, students do not form teams, seldom know others, do not collaborate and are not expected to work together. Their interactions are thus notably set-like. What they share helps them to solve problems, alleviate a sense of isolation, and discover different ways of seeing a subject. Many large MOOCs, though they may have designs that resemble those of conventional group-based university courses, are more set-like in social form, for similar reasons.

3 WHY DO PEOPLE CONTRIBUTE TO SETS?

For many contributors to the public good, social capital plays an important role: by providing help to others, one is increasing one's own social capital, with consequent gains for all concerned (Nemoto et al., 2011). This is equally true in a learning context (Daniel et al., 2003). However, this is not the whole story, even in tight-knit social networks, where expectations of reciprocity may not play a dominant role (Wasko and Faraj, 2005). A survey of frequent contributors to Wikipedia found that five of the top 67 editors (those who have made at least 500 edits) were known only by their IP addresses (Various, 2005). Amongst these anonymous contributors there can be no expectation of reciprocal social benefits. As a species, we have an evolved tendency towards altruism that cannot be simply explained away by assumptions that people rationally weigh costs and benefits. We are genetically inclined to help one another (Wilson, 2012). Beyond anonymous contributions, many sets emerge as a side-effect of other interactions. For example, academics may publish blog posts primarily for the benefit of a small subset of people in their own networks or groups, while knowing that there is an added benefit that their writings might be read by the set of others with a similar interest.

4 SET LEARNING

Set-based learning tends to be appropriate when the objectives of learning are already known. It is well suited to information seeking, inquiry-based and problem-based pedagogies, where goals are known and the learner already has some subject knowledge.

While people often help one another in sets, there tends to be little or no deliberate collaboration because there are few opportunities for sustained interaction, no shared projects, and limited scheduling of activities. Conversely, there are also minimal temporal or spatial constrictions on independent learning. Cooperation (not collaboration) is the dominant form of working together, in which learners working individually contribute to the learning of others. There is more sharing with others rather than direct dialogue and, when dialogue occurs, it tends to be fleeting and limited in scope. Where coordination does occur, it is either through centralized methods like FAQs compiled by individuals, or more sophisticated structural processes such as the forking process used in Github, that enables people working independently to contribute to one another's work.

Apart from sets that form around temporal events, most sets tend to eschew schedules and pacing. People tend to contribute as and when they want or need to do so. For those seeking answers to problems or discussions about issues, this can be frustrating, unless the set is sufficiently large to ensure a constant succession of contributors. However, the almost ubiquitous reification of previous interactions (including recommendations) means that answers previously given at one moment can continue to provide value to later-arriving members of the set.

Sets have great value in forming and building learning networks and even groups. For instance, on sites that form around (say) support for a specific piece of software, there is typically a caucus of enthusiastic contributors who come to know and respect or at least recognize the strengths and limitations of one another, leading to what may often be rightly described as a community. While there may be hundreds or thousands of occasional contributors in such spaces, and countless people who do not contribute, but do read, such spaces often contain rich social networks as well as sets. The non-contributors in such set-oriented spaces are often misleadingly referred to as 'lurkers'. This is a consequence of failing to recognize that sets are not communities as such, mostly lacking the norms and network bonds that hold communities together. It is as meaningless to describe readers of books as lurkers as to describe members of sets that way.

Sets are typically great for finding diverse views and perspectives, inasmuch as the shared attributes that bind the set together may have little to do with any other shared values. There are typically few dangers of group-think, nor of only connecting in yet another network with like-minded people. Despite the potential for this diversity they may also reveal underlying homogeneity that can be used as a basis of more intensive interaction. It should also be noted that some shared attributes such as religious belief, occupation or cultural origins, may be a shorthand for a cluster of shared attributes or set memberships. There is a world of difference between the set of religious fundamentalists and the set of people interested in learning to sail.

5 SET DISADVANTAGES

5.1 Focus

In order to learn in a set it is normally necessary to know what one wishes to learn. Unfortunately, knowing *that* is one of the most common challenges faced by a learner. Until one has been immersed in a subject, it is hard to know what questions to ask, - what sets to align with. There are some solutions. Many Q&A forums, for instance, are divided into categories such as 'help for beginners' and 'advanced topics', creating subsets with a learning focus. Similarly, every Wikipedia page supports and is the focus of a different set. Wikipedia provides plentiful links within each page to other pages, that a learner can follow in order to gain a grounding in a topic as well as to get foundational knowledge in many areas – exhibiting the learning potential of the set. However, set-based learning can be overwhelming unless the learner already knows the information he or she needs to seek. The paths through potential answers are multitudinous, so set-based learning can be circuitous and inefficient. Moreover, the information that is available may often be contradictory, and it can be hard for a beginner to distinguish the good from the bad.

5.2 Depth

Related to problems of focus, set-based learning typically tends to involve brief exchanges rather than sustained dialogue. This is fine if one needs an answer to a programming problem, but not great if one is seeking to become a medical doctor, where lengthy study crossing many disciplinary boundaries may be needed, and where a sustained path may need to be planned, with dependencies and prerequisites at every stage. The set may be able to provide help with constructing or advising on such a path, but it requires a fair degree of self-discipline, independence and self-determination to succeed. Typically, sets may provide help and support but, for longer learning journeys, are often best supplemented by networks and/or groups. Sets can provide the seed for these to emerge, with phases of peripheral participation leading to stronger involvement with networks of learning partners as time progresses. However, for set-oriented approaches like xMOOCs (sets with an interest in subject X) that often use group-oriented methods like tight schedules, there may be challenges of insufficient time for networks to form and learners needing group support may be set adrift.

5.3 Trust

One of the biggest problems faced by set-based learners is that anonymity makes it more likely that there will be trolls, spammers, scammers and other undesirables. Even when intentions are good, sets often contain members with limited knowledge as well as those with too much knowledge, whose attempts to help may be positively harmful. Inaccurate or scanty knowledge may result in poor foundations or wasted work, while excessive complexity or jargon can be demotivating to someone trying to make sense of the basics. Division of set into subsets with greater focus can help here, as can enthusiastic moderators, but more complex collective tools are often needed to address this problem.

5.4 Diversity

Part of the value of sets lies in the diversity of opinions, skills and interests of set members. However, this can come at a high price because people with different cultures, different vocabularies and different understandings may cause confusion, upset one another, or fail to communicate effectively. Sets are fertile ground for flame wars, angry debate and what some set members will see as irrelevant or unimportant. At best this can be inefficient, at worst it will drive people away from the set. Thus, this strength of diversity is also a potential weakness of disharmony.

6 THE ROLE OF COLLECTIVES IN SETS

Given the aforementioned difficulties, learning within sets can be frustrating, misleading, circuitous and poor for motivation. Collectives can provide the missing pieces to replace some of the guidance roles of the teacher and can make up for the lack of personal connection and relatedness that occurs in networks. The general principle behind any collective is that the actions of many people are combined, processed and represented, typically as recommendations, or for filtering, or to structure information or to suggest a path through it. Collectives can filter and help make sense of the information generated by the set (and, to a lesser extent, the net and the group). For example:

- An automated collaborative filter can find others with similar patterns of interest or behaviour, and recommend content that may be of value.
- A tag cloud can show topics of interest to a set, helping to get a better sense of the overall shape of a subject area and to make it easier to know what to look for, suggesting other things that may be of interest.
- A reputation system can identify individuals who have been found to be trustworthy or knowledgeable within a subject area.
- A rating system can help promote good answers/solutions/recommendations and demote bad ones.
- A data visualization tool can graphically display activities, actions or ideas of a set of learners.
- A crowd-sourced spam filter can help to remove content that is injurious or irrelevant

Collectives based on sets *can* be an embodiment of the wisdom of the crowd, with relatively few of the problems that can arise when individuals are connected or know what decisions others are making (Surowiecki, 2004). Sometimes, sets of moderately informed people can outclass experts when dealing with a range of tasks (Page, 2008). Collectives are, however, only as smart as the algorithms that underlie them and the combined wisdom of the crowds that feed them. This means that they tend to be susceptible to some common flaws, including:

- The Matthew Effect (Merton, 1968), in which the rich get richer and the poor get poorer, an out-of-control path dependency that makes it hard for better novel solutions to gain a foothold and the rewards priority and familiarity more than quality.
- Filter bubbles (Pariser, 2011), in which we tend to see things that resemble what we have already seen, limiting opportunities for serendipity and discovery of novelty. This is especially risky for learners who, by definition, need to enter novel territory.
- Lack of pedagogical model, so that it is not

always value to learners or even learning that is valorized in the results. Relatively few collectives explicitly support learning and most rely on some variation of popularity or commonality measures albeit, in the case of more sophisticated tools like collaborative filters, with significant personalization.

- Intentional abuse, in which mischievous or malevolent people, especially when working as in consort, can subvert or overly influence a system. 'Google bombing' and search-engine optimization strategies are good examples of this.
- Selection bias, in which a distinctive subset of individuals provides a biased collection of raw data on which to operate. For example, a student or a set of experts may fail to consider solutions to problems that are unconventional, and so miss some important opportunities.

While collectives have been used to good effect in an educational setting as well as offering a lot of value to informal and non-formal learners, it remains an important research area to find ways of adapting them effectively to the distinctive needs of learners.

7 CONCLUSIONS

The set is an under-researched social grouping that we have only recently begun to explore. The set has increasing importance as we move away from the familiar formal learning approaches of institutions that worked well in an industrial face-to-face context but that do not operate so well at Internet scales, and that do not cater well for informal or just-in-time learning. As well as being crucial in supporting day-to-day lifelong learning, the social form of the set dominates in large-scale MOOCs. However, many MOOCs are designed as though they were groups of a conventional academic variety, with schedules that assume group-like engagement and commitment, discussion forums that are often over-populated, fuzzy in purpose or that assume collaborative rather than cooperative pedagogies. As a result, they often carry unrealistic expectations of trust and shared intent that, in a large and diverse population, are unlikely to be achieved. This paper has begun to scratch the surface of how and why we might use sets for learning, as well as some of the pitfalls that await the unwary. We continue to research the differences and to build tools to support sets for learning. In our forthcoming book, Teaching Crowds (Dron and Anderson, in press), we explore these issues in greater detail.

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Higher Education Academic Staff: Professional Identity and Sense of Community as the Key to Enhancing Teaching Quality

The Culture of Sharing Educational Resources in the Catalan University System

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Keywords: Catalan Universities, CIRAX, Collaboration, Community, Institutional Repositories, Open Educational Resources, Professional Identity, Teaching Quality.

Abstract: This study presents an analysis of the main features of teaching community of the Catalan university system, from both the individual activity of professors and the sense of belonging to a community. The basis of the present study is the meaning and the sense of community: a required factor for collaboration between professors, sharing and reusing teaching resources and, for ultimately, the success of a teaching and learning resources repository. Common goals that determine a community of practice can encourage collaboration through the network. The discussion presented here is based on the analysis of the pilot program "Col·laboratori Interuniversitari de Recursos d'Aprenentatge en Xarxa" (CIRAX), developed in 2013 in the field of teaching and learning introductory mathematics in the Catalan university system.

1 INTRODUCTION

In 2013, in the context of the European Commission's Opening up Education initiative, "Col·laboratori Interuniversitari de Recursos d'Aprenentatge en Xarxa" (CIRAX) was born. CIRAX is an interuniversity program funded by the Catalan government and its pilot-experience has been developed by lecturers of introductory mathematical courses at different Catalan universities. This project was basically motivated by three factors:

a) Transverse opening movement (Openness), which led into the development of ICT.
b) Communities of practice which share knowledge across the network.
c) Necessity to ensure a qualified Higher Education to respond the Europe 2020 strategy for smart, sustainable and inclusive growth.

In order to improve the teaching quality at university, this project aims to promote and consolidate a teaching community which should be active in the creation, updating and sharing resources, and learning practices. The tool for achieving this goal is a *repository-in-collaboration* where resources could be shared, well-catalogued and well-managed. It should facilitate a subject preparation as well as the sharing of proposals and teaching works. CIRAX pilot experience allows us to analyse the role of teaching at universities and its quality, while putting particular emphasis on the higher education academic staff identity and the sense of community, as a success factor for collaboration, sharing and reuse of open educational resources.

Different sections of this article describe the different issues surrounding the utilization, sharing and reutilization of networking resources in the Higher Education context, in our territorial framework and within mathematics academic community.

The first section contextualizes the teaching activity in Spanish Higher Education. The second part points out to some basic ideas about the definition of the sense of community, as well as some features on professional identity. The third section focuses on the existence and coexistence of different online repositories and platforms, as well as their utilization. Then, it sets down the way in which Catalan university system values teaching activity at university and, consequently, what is understood as teaching quality in Higher Education. Finally, it connects CIRAX experiences with the previous sections. Thereafter, in the last section we remark the most important experience outcomes and show some final thoughts in order to suggest future lines of action.

2 TEACHING ACTIVITY IN HIGHER EDUCATION

In Spain, university faculty has three tasks: teaching, research and management. Two of them are not always easily separable: one linked to the teaching and learning process and the other one tied to deepening their own knowledge. For this reason, it is said that university professors have to deal with a dual identity: one related to being a specialist in the field of science, and the other, to be a specialist in the development of teaching-learning processes in the same discipline (Fernández, 2011); (Peña Calvo, 2012); (Zabalza, 2009). Despite the fact that these basic tasks are known, they are not differentiated or understood as they should be. For that reason, working with these two identities is not a simply task.

In the context of Higher Education, professional identity of academic staff has been analyzed from multiple perspectives, but not many of them study the university professors' teaching concepts or their feelings regarding this activity (Badia, 2011).

Sancho (2001) classifies the characteristic traits of Spanish academic staff. According to her study, it is, for example, common to hear about research teams, it is not so common to hear about teaching teams. Another characteristic is that teaching at university is often reduced to be rather private in nature. In general, most teaching activity remains between professors and their students and educative projects are usually accepted without revisions or external controls.

EHEA's (European Higher Education Area) aim is to improve the quality of their programs and degrees. Its main goal is to ensure the quality of the education offered, in order to cope with a fast growing and internationalized higher education demand.

The problem, then, lies in the definition of a teaching community at university, its members and their operational dynamics within the European Higher Education context.

Marin (2004) argues that relationships formed by a university professor both with students and colleagues are probably the elements that most strongly affect teaching, especially during the period of induction to professional practice. This is because these relationships help to determine methodologies, beliefs and attitudes towards the university in general, and in particular, in relation to the development of their work.

In this context, Mas Torelló (2011) indicates that although university professors work for the highest level of educational institution that exists, mostly of them are not trained in teaching. They enter the university system after learning about their chosen field of study in higher education institutions, without receiving any teaching training.

These ideas are summed up by some authors, like Marín (2005), Show-Gerono (2005) or Zabalza (2009), who suggest that professional development of teachers in the new university educational system requires dialogue and collaborative work, as a training that enhance not only teaching skills, but also the whole person, both personally and professionally.

As Zabalza (2009) pointed out, regarding teaching "it is imperative that (the people who teach at university) have to be satisfied with their salary levels, prospects for promotion and treatment, the intellectual challenge of research the pleasure of teaching and emotional quality of communities of practice in which they work" (Knight, 2005).

Sancho-Vinuesa (2013) claims that a local policy framework is established and it can help to define professional identity regarding university teaching. Nevertheless, an adequate teacher training, a system of incentives, an appropriate recognition criteria and values of quality and prestige, would allow to shape it. Therefore, a definition of various profiles, a weighted system of incentives and appreciation of teaching could definitely contribute to the review the professional identity of university faculty (Sancho-Vinuesa, 2013). This framework should promote teamworking, sharing experiences and peer review, basic elements for the quality of educational system.

3 SENSE OF COMMUNITY

There are different definitions of "community" and "sense of community". Rovai (2002) points out that community dimensions depend on specific context. Likewise, there are some aspects which are basic for members of any community: mutual interdependence, sense of belonging, linking "relationship", spirit, trust, interactivity, common expectations, shared values and goals, and co-lived stories. Specifically, the same author argues that members of a group have feelings of belonging, confidence and have obligations to others and to the institution. Of course, they have a shared conviction that the educational needs of all members will be met through their commitment to shared goals.

King (2003) points out that “professional identity” is a key element with which analyses the factors that influence resistance to change in institutional contexts.

Beyond the factors that explain the involvement of people in institutional innovation, which has been analyzed from multiple perspectives (Shaninina, 2003), it is interesting to know the reasons why some people remain committed to innovation and sustained change in shape and others are not. Sharratt (2003) states that sharing knowledge within a community reflects a moral obligation, which corresponds to a personal feeling more than other factors. Consequently, if there is a “community”, the sharing of knowledge would be stronger when the sense of community is stronger. Davis (2010) considers that altruist sharing is not enough by itself and needs to be accompanied by more pragmatic selfish motives.

In this context, on the one hand, we wonder whether a definition of a community and professional identity of university professors in the sense of teaching and learning process is possible. On the other hand, we think that advantages of sharing need to be integrated by the community in its day-to-day teaching practices, in order to reinforce a sense of community belonging and motivate exchange and dialogue between members.

4 REPOSITORIES AND SHARING ENVIRONMENTS

The introduction of ICTs has had a very direct effect on the format of educational resources and the way that they are stored and distributed.

Governments and educational institutions have devoted much effort in the development and implementation of institutional repositories, but not much in assessment in relation to the participation of teachers. There are some recent studies (Davis and Connolly, 2007); (Davis, 2010) that have analyzed the low usage in terms of content and participation in the service offered from university libraries. It is a fact that this poor use of institutional repositories is not only a local concern, but there are some questions that are valid, wherever the learning repository is: institutional, local or global, thematic or by discipline. In this section we identify the factors that influence in the participation and resource sharing in the Catalan university system, focusing on the variety of repository strategies, professors’ behaviour and organisational structures.

While there is a widespread use of educational platforms, preservation strategies of teaching materials are diverse, and rarely both environments have been joined or integrated to facilitate exchanges between the repository and the virtual classroom or platform. In this sense, we realise that there are two environments managed by different actors and focused on different aims. Learning management systems are managed by lecturers themselves in order to connect resources and students, and repositories are managed by librarians and serve preservation and informational needs.

According to different authors (Davis, 2007); (Bueno de la Fuente, 2011), the success of projects such as educational repositories often involve different strategies, both human and cultural. The review conducted by Bueno de la Fuente and Hernandez (2011) exposes different factors that determine the success of an institutional repository with learning resources: conceptual and pedagogical, human and cultural, political and organizational, legal and technological. Repositories that can be divided by collections need not only allow depositing resources, but provide a favourable environment to enhance dialogue and communication.

This explains why in the framework of projects which promote the sharing of open educational resources, different models of organisation have been described. While the technological tool could be similar, attitude and its integrative dynamics can produce organizations that differ according to the presence of a collaborative goal. On the one hand, the social network becomes a meeting and exhibition space for its users. On the other hand, the community of practice goes beyond coexistence in space and is characterized by collaborative and common goals of its members (McAvinia and Maguire, 2011). Both phenomena are interrelated or lived separately.

In addition, these communities of practice among teachers become stronger when they are based on a specific theme or built from personal relationships (EdRene, 2010). In other words, a criterion is needed that groups the actors in the community and acts as a common goal, in order to increase the perception of belonging. Some open educational resource projects also include a community coordinator who also has expert insight into the discipline. Other projects let librarians lead communication tasks and stimulate collaboration.

In our study, we consider the fact and the desirability of sharing resources and teaching experiences. The next section will show how organizational and institutional factors take part in sharing culture, and show how they may influence teaching quality.

5 TEACHING QUALITY

In general, management, participation or membership innovation teaching groups or projects is viewed favourably for Catalan universities[1]. However, aspects of collaboration or cooperation between the members of these groups or projects are not specially valued in most of them. The situation is the same regarding the publication of educational resources in the institutional repository, which is not mandatory for most of Catalan universities.

Creation of teaching materials, developing specific experience with teaching methods or be the author of teaching-learning process documents is recognised by Catalan universities, but not in the same way in all institutions. For example, only one of these universities clearly sets out the creation of multimedia resources, another university appreciates the use of own resources and only one university takes into account the fact that resources can be shared or reused in some sense.

Each Catalan university has its own virtual platform that professors can use for their teaching activities. Although some universities encourage professors to use them, only one of the universities considers and consequently positively values the fact that resources stored on these platforms can be shared, used for collaboration or reused.

Few Catalan universities recognize the worth of openness and accessibility of teaching material to others via a virtual space and only one university contemplates the idea that this material could be shared. Moreover, the system of assessment of some universities does not value the use of educational platforms as a repository of educational material or for outreach publications.

It is clear that the common aim of sharing and re-use of resources such as teaching materials, and collaboration between professors to enhance them goes beyond what professors and departments can achieve themselves. The resources, designed and used by professors, are the common point of collaboration. University establishes the common structure of a course and a specific team teaches the lectures. All of these entities would have to go in one direction and recognize the same practices.

6 CIRAX EXPERIENCES

Through the CIRAX pilot experience, which involved 150 people (lecturers, librarians and IT staff) we confirm and justify several of the ideas discussed above. They allow us to think that a sense of professional identity and a sense of community is the key to collaboration among university professors and, consequently, to enhance the quality of teaching in the European High Educational context.

According to Academic Library Consortium of Catalonia (CBUC) librarians, most professors have been reusing teaching and learning resources in a spontaneous and uncontrolled way. This perception is shared by professors, who recognised that they have generally shared materials among department colleagues, and above all, colleagues of the specific course. Both, librarians and professors, assume that in general professors have a strong sense of ownership of their own teaching resources. Moreover, it is claimed that educational materials differ from scientific publications because the first one is alive and is never closed. These facts confirm that cultural factors can play an important role in enhancing or inhibiting sharing.

The diffused information through CIRAX that sparked more interest in professors was related with the announcement of new resources hold in CIRAX and related with the recognition for the material hold in CIRAX which caused more expectation during the pilot experience. These facts allow us to think:

a) Professors are interested in knowing possible new resources for their teaching activity and they are grateful for an easy way to finding them out.
b) Recognition for teaching work, in terms of developing or sharing teaching resources encourage lecturers to create, use, reuse, modify or collaborate on teaching materials.

Most of professors involved in the CIRAX experience complained that they do have not enough time to explore new platforms or resources. For this reason, they would appreciate more transversal teaching resources, which will make research easier and faster. To achieve information retrieval, it is necessary to have a system that is both robust and flexible, but in the pilot, professors claimed that thematic classification is crucial.

From interviews to professors carried out during the project and from a final questionnaire, professors involved in the CIRAX experience emphasise that teaching resources should remain bounded in a specific and reduced context around the topics of their courses of subjects. They require a small environment for colleagues that share the same interests and work on similar topics.

As stated above, in Spain, teaching resources are not revised in the same manner as research papers. In relation to this, through the CIRAX pilot, we detected that professors who wish to reuse materials require a teaching guarantee of shared resources. However, during the I CIRAX Day final roundtable a great number of authors of materials claimed that revision of this material is not necessary. Autocratic and self-revision could be useful instead, as well as simple exposure to maths community. Thus, in order for all professors to share and collaborate, focusing on enhancing materials, an agreement regarding this will be necessary.

7 CONCLUSIONS

Open Educational Resources and Teaching Practices in Europe 2013 show that in the European Higher Education context, collaboration and sharing are fundamental practices. They allow the enhancement of teaching activity and, therefore, the learning process and professional development.

After the CIRAX pilot, we realised that despite the fact that these practices are accepted by most of the higher education staff, there are some barriers, mostly cultural, which do not facilitate the collaboration and sharing to take place. Nowadays it is still difficult for university staff to share or reuse teaching resources and, consequently, collaborate with each other, especially when they come from different institutions.

Collaboration requires a specific and well-defined community to succeed, where each member has a clear idea about his or her professional identity. What faculty have to do in order to be an excellent professional? Regarding to this, the recognition and value of teaching practice as well as the definition of a professional career in a Higher education institution becomes a key factor. To incorporate mechanisms for the evaluation of teaching (relatively standardized through universities from Catalan system) as well as incentives, not only economical, but in prestigious sense for teachers in their daily dedication in teaching, and encourage teamwork like in scientific field. These strategies could support professional identity and enhance community collaboration.

Altruism, recognition and prestige are basic elements for collaboration, but they are not possible without a main element. This is the identity, the feeling to be part of a (specific) community.

Achieving this objective goes further than only a feeling. Sharing and reusing requires a stronger link than just to have common goals. It requires a stronger level of support and help. In addition, evidence from this pilot study points out that professors' engagement does not happen on its own. Diffusion and communication activities are elements that reinforce this engagement, like a Community Manager in other social networks.

In a nutshell, two factors are identified in order to guarantee a real collaborative work among academic staff: a) the definition of a professional identity in the case of faculty members; b) the existence of a specific community which share knowledge, values, expectations and goals. If professors know that teaching activity will be assessed and recognized, and they belong to an active teaching community in a specific area, there will be the basis for a teaching which follows the quality standards on research activity: peer review, openness and teamworking.

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APPENDIX

[1]Each Catalan University has its own Manual d'Avaluació Docent (MAD) that specifies which teaching activities are recognized. The Agencia per a la Qualitat del Sistema Universitari de Catalunya is responsible to set up common criterion and validate each MAD.

Guided Participatory Research on Parallel Computer Architectures for K-12 Students Through a Narrative Approach

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Abstract: The approach to computer science (CS) education is typically geared towards the knowledge of the principles behind information technology, but there are social indicators that it overlooks some important educative aspects such as thinking competences and social attitudes. Such aspects play a fundamental role when bringing CS education to the K-12 level. In order to enable a truly educational experience, we propose to bring specific CS research problems within reach of K-12 students, because the active knowledge construction process that takes place during research requires children to be engaged with all of their knowledge, skills and attitudes. This poses the challenge of overcoming the knowledge gap of students, which we address by means of a synergistic cooperation of CS experts and educators. More specifically, we propose the narrative approach as the key enabler for CS participatory research with K-12 students.

1 INTRODUCTION

Computer science (CS) and the technologies it enables now lie at the heart of the way students live their lives, especially in school and entertainment environments. The ubiquity of information technology is frequently cited to support inclusion of CS in secondary education. The starting point for this work is that even learning-objective-oriented approaches to CS education (Sawyer, 2009; Pasternak, 2012) in many cases end up accounting only for some educational elements (e.g., programming skills), while leaving the remaining ones (e.g., social skills, self-confidence, motivation, curiosity) to other disciplines (psychology, pedagogy, sociology). In practice, however, any CS curriculum develops social attitudes and thinking skills, even though they are not explicitly accounted for in curriculum design. The unmistakable proof of this matter of fact is given by a generalized lack of interest in science curricula in secondary and tertiary education. Another side effect is that thinking competences such as creative, critical and care thinking are not evolved to the same extent of technical knowledge and skills.

In order to overcome this gap, we value the research experience as a highly educative one, since it consists of an active knowledge construction process where the subject is engaged with all of his knowledge, skills and attitudes. For this reason, we aim at bringing research experiences in CS within reach of the cognitive capabilities of K-12 students. It is in fact at this stage of education that long-term attitudes start shaping up.

In order to overcome the common “black-box” approach of children to the media-rich electronic devices that are pervasive in their lives (e.g., smartphones, game consoles, laptops, etc.), the object of the proposed research experience will be the prototype implementation of a networked parallel computer architecture, which provides the needed “intelligence” to the above devices.

The main challenge we face in this project is to adjust technical depth, contextualization, and exemplification to the audience’s stage of cognitive development. From a pedagogical perspective, an effective way of making complex concepts accessible to young students is the narrative approach, since narrative thinking reflects the basic and powerful forms in which we gain knowledge of the world (Egan, 1986). Therefore, stories support the possibility to explain phenomena by creating narrative forms of models of industrially created objects (Fuchs, 2013).

For the sake of our research framework with children, we identify grid street plans of modern cities as an effective metaphor of on-chip interconnection networks, which provide the needed communication and integration function to modern parallel computer architectures.

For the success of the proposed approach, the synergistic and inseparable cooperation of pedagogists and CS researchers at all stages of the implementation is a mandatory requirement. In fact, such cooperation should complement depth and breadth of knowledge about CS with pedagogical content knowledge (Cochran et al., 1993).

2 MOTIVATION

Today, teaching science at school is one of the major challenges for education. The Eurydice Report on the development of key competence at school in Europe (2012, p. 43) stresses the following factors:

- young people lack of basic skills in mathematics and science;
- there is a declining number of higher education graduates in MST (mathematics, science and technologies) fields.

Since education has a pivotal role in order to reverse this negative trend, what seems to be urgent is the necessity to impart new vigour to science education in order to raise student's interest, knowledge and skills. Our contribution is thus a methodology for the realization of an educative experience in science education at school.

We consider the present situation of science education to have its roots early in the school system, where abilities, preferences and disabilities start shaping up. Thus, we develop educational strategies for students at the K-12 level.

While CS is firmly established in higher education, introducing K-12 students to CS remains a major challenge, since it implies to address the pedagogical issues associated with adapting the level of technical detail to students at varying levels of cognitive development (Knobelsdorf, 2013). Recent learning theories such as constructivism, activity theory, and situated or distributed cognition theory, as well as work conducted in the interdisciplinary field of the learning sciences, are trying to tackle the problem, although this effort is still in the early stage.

One relevant evidence from the application of the constructionism theory is that learners are more likely to be intellectually engaged when they are working on personally meaningful activities and projects. In this direction, designing and creating simple digital objects (a webpage, a small program or a simple hardware device) was shown to rise the curiosity to acquire the foundation of factual knowledge (Knobelsdorf, 2011). However, one common misunderstanding is that there is no reaction of what is studied upon the development of the person learning, upon the tastes, interests, and habits that control student's future mental attitudes and responses. In practice, these personal elements are collaterally formed. This is an evidence that stems from sad matter of facts: for instance, CS education may lead to students that are largely engaged with computer programming, but at the expense of the development of social abilities and skills; moreover, this might not be reflected into the formation of attitudes that decide the uses to which the ability is to be put on.

Another common embodiment of constructivism consists of setting up environments for learning programming such as Logo, Scratch or Lego Mindstorm. Although these learning environments are engaging, students do not automatically obtain a clear and systematic understanding of programming concepts (Meerbaum-Salant et al. 2010). In our approach, the entry point into CS is not simply working with technology, but rather a research experience that leads students to "discover" the basic principles of complex electronic devices of common use.

This choice stems from the awareness that students succeed in developing domain-specific competencies when their learning corresponds to authentic situations, where tasks and problems arise not from pedagogical concerns, but rather from the real-world (Collins, 2006). Because CS knowledge mostly consists of abstract concepts or problem-solving strategies, we propose an effective way of contextualizing this. We thus present a concrete instance (a real prototyping platform) as well as the underlying abstract principle (on-chip networking), so that students not only develop a general understanding of the concept in question, but also learn to apply it in different situations.

3 PROPOSED APPROACH

3.1 Methodology

We target the incorporation of a project-based experiential learning experience into the K-12 students' curriculum in the form of a guided research experience on selected design and optimization issues of a real-life electronic device prototype. *The ultimate objective is to enable the basic understanding of the working principle of modern media-rich electronic devices, AND to foster the "researcher mind-set" in the students.* The goal is that the latter get used to the knowledge construction process of CS researchers, since we identify in the research activity many attributes of an authentic educative experience while teaching the science behind IT.

This holds promise of increasing students' motivation to learn as well, especially in the technology field, thus triggering a positive feedback on future school-choices and professional careers that can potentially reverse current negative trends in the long run. The ultimate reason is twofold. On one hand, students get a "real-time reward" for their uptake of the knowledge construction process: the possibility of making inroads into the working principles of those electronic devices that are pervasive in their life. Students in fact tend to consider them out-of-reach of their knowledge capability because of their complexity. On the other hand, students are brought to the stage where they can explore part of the design space of such devices, through a guided research experience, with positive implications on self-confidence and curiosity.

In practice, our approach aims at bringing participatory-research with children (Christiansen and James, 2008; Mortari, 2009) outside the boundaries of humanistic studies, where it has been mainly experimented so far. Some added values of project-based learning based on a real problem from CS research are:

- In the real world, knowledge (and its application) is integrated, rather than split artificially into subjects. Moreover, problem-solving is not a school exercise with a predefined set of answers but rather a complex engagement of an authentic issue with multiple potential solutions (inquiry-based learning). This feature, first characterized by Dewey (1938), remains the distinctive hallmark of experiential learning, central to our approach.
- It implicitly sets a broad range of learning objectives that contribute to all of the pillars of lifelong education, as identified by Delors (1996): learning to know, learning to do, learning to live together and learning to be.

The research experience needs to be guided by a CS researcher from academia or industry for a number of reasons, associated with his technical expertise as well as with the different educational interaction that he potentially raises in students (Tenenberg, 2010; Fincher, 2013). He can point out some key design choices that students would have never thought about. He can also encourage students to think more deeply about the problems, rather than simply grasping "good enough" answers. Finally, students experience increased relatedness to a technology-related profession, and to the practice that the researcher exposes them to. Simply speaking, the feeling of "serious work", of "complex work made accessible", and of "doing things right" clearly increases students' motivation.

3.2 Experimental Research Setting

Between 2000 and 2005 a fundamental design paradigm shift took place in the field of computer architecture. The application demand for more performance-per-watt, especially in the embedded computing domain, caused traditional monolithic high-performance microprocessors to evolve toward multicore architectures. In practice, the processing workload started to be split among a number of concurrent computation units, thus materializing congruent multiples in performance speed-up and power efficiency. This trend is currently well underway, to the extent that manycore architectures start to appear, that rely on hundreds of concurrent processing units implemented onto the same integrated circuit. The key component of a highly parallel computing architecture consists of an on-chip interconnection network (Network-on-chip, NoC) capable of networking the processing cores together onto the same parallel hardware platform. Further technical details can be found in (Bertozzi and Flich 2012). Our approach therefore aims at familiarizing K-12 students with the paradigms of *computation parallelism* and *on-chip networking*, which are revolutionizing architectures and applications in the embedded computing domain.

For the sake of keeping the research experience focused, it will concern the routing problem in NoCs. This latter consists of finding performance-efficient routing paths for network packets to reach their intended destinations. Feasible solutions to this problem have to meet the deadlock avoidance concern. Deadlock consists of a permanent blocking condition of network traffic due to circular dependencies in the routing channel request pattern. Overall, during the research activity students will have to devise feasible routing algorithms while assessing the absence of such circular dependencies. Moreover, such routing algorithms will be comparatively assessed from the viewpoint of their effects on congestion and implementation complexity.

At this point, the relevant problem of overcoming the knowledge gap of K-12 students arises. Addressing this problem requires a cross-fertilization with findings from pedagogy research.

4 THE FIGURATIVE STRUCTURE

4.1 Narrative Approach

Is it possible to teach very difficult scientific concepts to young students? Different educators and psychologist have considered this question and diverse answers were given.

The psychologist Jerome S. Bruner (1966, p. 33) wrote: “Any subject can be taught effectively in some intellectually honest form to a child at any stage of development”. Following Bruner, narrative and propositional thinking are the ways in which human beings structure their knowledge (Bruner, 1986). Usually, at school, sciences are taught using formal language and logic-scientific thinking (namely the paradigmatic one). Our proposal considers a second opportunity: using the narrative form to introduce formal and scientific knowledge. Developing narrative understanding of the science would complement the introduction of formal explanations of how the world works.

Indeed, the elements of narrative are not foreign to formal scientific understanding (Fuchs, 2013). Stories can be used to deepen our understanding of some physical concepts (e.g., in Fuchs’ work: the gestalt of forces and its aspects), because schematic and metaphoric structures are part of our everyday’s life, in particular of children’s one.

Story form is a cultural universal which ‘reflects a basic and powerful form in which we make sense of the world and experience’ (Egan, 1986, p. 2). Children especially use personal narratives to order and explain the complexity of their experiences of the world (Engel, 1999). Gallas (1994) presents how children talked and wrote about science, and reports on the complexities of the language and the stories they used to understand the world of science. Using narrative forms help children to get introduced to the complexity of the world through an approach that respects the form of their knowledge and their human mind.

In applying this approach to our research experience on parallel distributed computing, we are facing two distinctive and unprecedented challenges:

- The definition of a figurative structure that makes on-chip interconnection networks and their system integration function accessible to K-12 students through a suitable metaphor.
- The application of the figurative structure to an open-situation (i.e., the research experience). Thus, the figurative structure should be realized as a plot, rather than as a full and “static” story serving the purpose of bringing pre-defined concepts within reach of the cognitive abilities of students. The plot of the story would be in fact the metaphor for the constraints and operating conditions of a real multicore processing environment. Pre-defining only the plot enables the students to evolve it and complete the story, by following a driving question provided by the CS researcher. Providing answers to the stated question will enable students to augment the plot with missing details, which correspond to technical solutions to a specific research problem in the physical domain. Solutions to problems will be derived by students in a collaborative way, under the guidance of the CS researcher, who will lead the in-class research.

4.2 The Narrative Approach at Work

The in-classroom research framework we propose will be structured into a seven step methodology:

1- Setting the path to the research experience by an in-class presentation of the CS researcher bridging the gap between students’ pre-knowledge and the concepts needed to start the experience.

2- Definition of a figurative structure capable of overcoming the technical knowledge gap of students with respect to parallel computing and on-chip networking (see Section 4.3).

3- Presentation of the figurative structure to the students, with a clear distinction made between predefined vs. undefined elements. The former ones are the outcome of pre-taken design decisions (e.g., the figurative structure for the routing mechanism) and/or operating conditions in the physical domain (e.g., synchronous operation), while the latter ones represent the available degrees of freedom for design space exploration (e.g., the figurative structure for the routing algorithm).

4- In-classroom collaborative research, where the students will work out their solutions to the routing problem under the guidance of the CS researcher. This will not be done directly, but by reasoning on the corresponding problem in the figurative structure.

5- Selection of the best candidate routing solutions for prototyping on a real on-the-field programmable hardware platform, and definition of a set of quality metrics and experiments for their comparative assessments.
6- Taking the field-programmable hardware platform (FPGA) to the classroom, after the implementation variants of the routing framework have been pre-implemented and made quickly interchangeable. Running the experiments and collection of experimental results that should then be properly structured for discussion (tables, figures).
7- Discussion of experimental results, with the CS researchers having the key role of stimulating the association of observed macroscopic results with the low-level details and effects taking place in the figurative structure of the hardware platform.

The researchers will lead the research activity supporting students to identify questions, formulate hypothesis, design solutions and problem-solving strategies through dialogue and collaborative work groups.

In order to guarantee the feasibility of the methodology, two fundamental requirements need to be fulfilled in the hardware prototype:

- Implementation of a networked multicore system with fast reconfiguration capability of the routing function. Runtime reconfiguration of the routing algorithm should not imply the recompilation of the hardware platform, so to meet timing constraints of a class lecture.
- The platform should be equipped with a graphical user interface for the sake of specifying hardware parameters, collecting statistics and/or monitoring specific functional effects while the system is running. For this purpose, the GUI should reflect the chosen figurative structure, and graphically associate events in the hardware platform with those in the figurative structure.

4.3 The Grid Street Plan Metaphor

The figurative structure of our on-chip interconnection network is realized through the metaphor of a *grid street plan* of a modern city (such as New York City). Grid street plans are the metaphor of 2D mesh topologies for NoCs in the physical domain. The students will therefore explore the design space of NoC routing algorithms by taking routing decisions in a grid street plan. The metaphor is so effective that in the early stage of on-chip networking routing mechanisms were directly inspired by the paradigm of driving directions (Borkar, 1988). The key requirement for the metaphor to hold consists of an initial alignment of the metaphor to the feasibility space of NoCs. In fact, the direct transposition of the grid street plan implementation details (e.g., crossings, roundabouts, traffic lights) to the NoC domain does not result in efficient solutions. For instance, street crossings managed via traffic lights or via the right-hand precedence rule would result in poor communication bandwidth in the electronic domain, since some traffic streams would block other ones although heading to different destinations. As a consequence, the students will move from this consideration and will be guided to design street crossings and grid networks for which the metaphor holds, although the resulting solutions will certainly be a cost-overkill in a real city. In this direction, crossings will be engineered in such a way that every arriving direction is theoretically connected with all other directions in a collision-free way. This implies the implementation of multi-layer street crossings, following the paradigm pictorially illustrated in Figure 1.

Figure 1: Multi-layer street crossing as a metaphor of NoC switches.

5 PREVIOUS RELATED WORK

The challenge to apply the narrative approach to science education has been tackled by several authors in the past (Fuchs 2013, 2007; Corni et al., 2010). We refer to them in order to base our proposal on a reliable pedagogical framework, which is based on the narrative and story structure of human knowledge (Egan, 1986; Bruner, 1986).

In his work, Fuchs (2007) creates figurative conceptual structures for understanding physical processes as a collection of force-dynamic gestalts (quantity, quality, and power). These aspects are structured with the help of metaphoric projections of image schemas. The application of analogy to the various fields of continuum physics lets him recognize a fundamental yet simple conceptual structure - the same as that used in much of human reasoning, not only in physics but also in psychological and social situations.

Another example is provided by Falk, Herrmann, Job, and Schmid (1983), who developed an approach to teach Gibb's thermodynamics stressing the use of substance-like quantities.

We find that the exploitation of the narrative approach for science education is only in the early stage. Our novel contribution consists of using it as a key enabler for a research experience with K-12 students. This implies not just the investigation of a figurative structure for multicore processors and their interconnection system, but also of its suitability for "on-the-field" evolution.

6 CONCLUSIONS

We propose an innovative approach to CS education at the K-12 level. Our main idea consists of bringing research experience on parallel computer architecture within reach of K-12 students, thus jointly developing their knowledge level of the matter as well as their personal attitudes. The key enabler consists of the narrative approach, which we exploit to overcome the technical knowledge gap of the target students.

Our future work consists of further developing the NoC metaphor and the HW/SW prototype for the research experience, and of testing it in Italian middle schools.

An educative research (Creswell, 2002; Mortari, 2007) will be conducted on this experience in order to produce qualitative evidences about the impact of the educative experience on the children's thinking. Qualitative research tools such as video and audiotapes, interviews and written tasks will permit to collect data about the experience itself and the subjective student's responses. A qualitative analysis of these data will guarantee the possibility to describe and assess the expected impact.

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Investing in Ephemeral Virtual Worlds
An Educational Perspective

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Keywords: Virtual World, Virtual Reality, Virtual Learning, Second Life, Opensim, Persistence.

Abstract: The increased demand for the use of virtual worlds in higher education has led many educators and researchers in in-depth analysis and evaluation of a number of different virtual environments, aiming to highlight their potentials. Until recently, Second Life was one of the most widely used virtual worlds for educational purposes. However, the decision of Linden Lab to stop offering the educational discount, the rumours around its future and the emergence of a novel technology called OpenSim challenged institutions' decisions to keep using Second Life. In a try to identify the way institutions make their decision to use a virtual world, 34 interviews have been conducted with university educators. The results of this study reveal that both the cost and the persistence of a virtual world play an important role on this decision. However, there are still some unique benefits offered by each world affecting to a great extent the educators' decision. We conclude the paper by advocating the use of a cross-institutional hypergrid.

1 INTRODUCTION

While much of research on virtual worlds (VWs), and in particular Second Life (SL) – the possibly most prominent of these – has been performed about projects within the VW itself (Bredl et al., 2012; Childs, 2010; Miller et al., 2010; Vosinakis et al., 2011) it would be naive to restrict oneself only to the "inside" of these worlds and ignore the "real world" environment in which these exist. The relevance of this aspect has been already highlighted by Shukla and Conrad (2011) who identify such experience external to the VW via the notion of "broad environment" and "direct environment". Specifically for the educational use of VWs the concurrent consideration of both an "intrinsic" and "extrinsic" view led to the development of an evaluation framework (Conrad, 2011) that, in further discriminating into an "individual" and a "world" aspect identifies the four dimensions: cost, persistence, context and immersion.

Since the authors have already examined the "intrinsic" perceptions of the use of VWs in previous works (Christopoulos and Conrad, 2012; Christopoulos and Conrad, 2013), this paper aims to enlighten its extrinsic view of persistence, focusing on three specific VW paradigms: (i) SL, (ii) non-isolated VWs based on the OpenSim (OS) technology and hosted by Dedicated Providers (OSDP), and (iii) isolated and closed VWs based on the OS technology and hosted Internally (OSIH). At this point the fact that OSIH can also be open and interconnected through hypergriding is essential to be pointed out. However, this case is not in depth analysed in the following sections.

In this paper first we provide a short and summative account of our results concerning Immersion and Context in so far as they are relevant for the further discussion on the extrinsic dimension of Cost. The main sections on Persistence then contrasts the view found in the literature (Section 3) with educators' opinions on these themes derived from our interviews (Section 4) and analysed via Grounded Theory (Strauss and Corbin, 1998). The findings of this paper (Section 5) are based on data collected and analysed within the wider context of a Masters by Research thesis of one of the authors (Christopoulos, 2013). We conclude the paper by highlighting the authors' position on how to move forward.

2 IMMERSION & CONTEXT

Many attempts have been made to evaluate the context of SL and OS based VW's (Diener, 2009;

Miller et al., 2010; Vilela et al., 2010). In one of our previous works (Christopoulos and Conrad, 2013) we comparatively examined these and concluded that both SL and OS have many positive and negative features in common as far as their contexts are concerned, but at the same time, one differs from the other, each having its own separate positive and negative characteristics. However, the negative elements of these worlds are not powerful enough to discourage academics from exploiting them in education. It became apparent that both SL and OS can cover various needs that are difficult to be covered or may not be covered effectively through the use of the educational tools of the physical world. As a result, educators consider each one of them suitable for different types of educational activities.

In addition to context, several researches have been pursued to quantify immersion (Bredl et al., 2012; Childs, 2010; Vosinakis et al., 2011). Indeed, VWs are not immersive by definition (Christopoulos and Conrad, 2012). Taking into account the features of SL, it seems to be coming first in preference, however slight it may be, over OS. These two VWs were judged by educators as almost equivalent in developing a sense of presence to students, but the broader and richer network of interactions that exist in SL gave it the lead. Second in line come the OSDPs, and last of all come the OSIHs.

Unlike context and immersion, very limited studies have been conducted regarding the cost and the persistence of such VWs. In the following two sections we therefore attempt to fill this gap and establish how educators view these two extrinsic aspects of virtual worlds. The findings are based on semi-structured interviews that are contextualized within the available literature.

3 RELATED WORK

Undoubtedly, the future of a VW and its persistence over time cannot be predicted with certainty. Nevertheless, the possibility of a VW stop operating is certainly not a pleasant prospect, considering the fact that educators and universities are based on it for the implementation of successful projects, investing time, effort and money on it.

Up until December 2010 Linden Lab was offering a 50% discount to non-profit and educational institutions for the acquisition and maintenance of land, a fact that encouraged the educational community to engage in SL. As from January 2011 that discount stopped being offered and that caused great inconvenience to the universities maintaining their virtual land in SL, since the cost became unbearable, and great displeasure to many educators using SL (Christopoulos, 2013). Even though a new discount came to replace the previous one, very few universities were able to be benefited from it (Harrison, 2010).As a result, some universities stopped using SL, some moved to other, cheaper VWs such as OS, while others opted to coexist in a shared piece of virtual land (Christopoulos 2013).

The universities, however, were not the only ones that left their spaces in SL. Even the private estates, the fees of which are the main source of income from SL for Linden Lab, decreased considerably during the previous years (Au, 2012). This obviously implies an income reduction for Linden Lab, which, according to estimates, will have to face serious economic problems (Llewelyn, 2012; Au, 2012), if this issue is not addressed to soon.

The “workspace sharing” practice of many universities in SL that aim to reduce the cost of using the world, without, however, losing the multiple benefits it offers, is not just a practice which only universities follow. It is a general trend of many individuals, businesses and educational institutions to opt to share a common virtual space, as well as its fees (Llewelyn, 2012).

Thus, the future of SL looks uncertain. Even more so, given the situation in SL and Linden Lab’s attitude towards educational institutions, predictions like this of Rogate (2012) should not be taken lightly: “SL as a product for educators is actually dead, unless something dramatically changes with the strategy of Linden Labs—which always remains unclear”.

On the other hand, although OS technology had several glitches and instability issues at its first steps, it has become considerably stable over time. The qualitative improvement of OS, in conjunction with its low economic cost of use makes it attract new users, whereas SL keeps losing them (Gracious, 2012). Therefore, OS has lately become a very worthy competitor of SL, since it has evolved into a VW almost as functional as SL (Reeve, 2012).

Moreover, the features of keeping backups of the world and hypergriding, i.e. the teleportation from one grid to another, are exclusive advantages of OS, which enhance its persistence over time. OS, essentially, is not a VW, but a technology open to anyone who wishes to develop a VW. This world can be backed up along with all its content at any time and reused whenever necessary, by anyone holding the backup files (Miller et al., 2010). This means that each VW persists for as long as its backup files exist and independently of the operation of the others (Fishwick, 2009).

4 EDUCATORS' VIEWS

For the needs of this study 34 educators were interviewed. The interviews took place through skype or within SL or OS. The questions asked were the following:

1. If Second Life were to close many educational institutions would be left "homeless".Have you taken this issue into account?What is your opinion?
2. Are you concerned about Second Life's closure? Does this possibility affect your decision to use Second Life?
3. If eventually Second Life terminates, will you attempt to replace it with another virtual environment? Can you, please, name this alternative solution?
4. OpenSim is a new technology used for the development of virtual environments. How stable do you expect this technology to be?
5. A major advantage of OpenSim technology is the opportunity given to its users to keep backups. How useful do you consider it?
6. OpenSim grids have the potential of "hyper gridding" (teleportation of avatars and items from one grid to another). How useful do you consider this fact?
7. OpenSim technology faces stiff competition from other well established virtual worlds such as Second Life. Thus, do you consider that this competition will affect negatively its persistence?

4.1 The Future of Education in SL

The spreading rumours about the future of SL and its potential closure raise interviewees' concerns about the future of their projects running in-world. They state that they worry less about their educational projects, which anyway may find shelter in other VWs, but more for research projects on SL which cannot be carried out into another world. They are also concerned about the resources spent for the needs of these projects that will be lost if SL terminates. Furthermore, the concern that, if SL terminates, its community and the thematic groups will be lost, was also expressed. Then, these groups will no longer be able to organize in-world professional events, which are considered to be very useful and constructive for professionals in any industry operating in SL.

However, some educators indicated that they will continue using SL for educational purposes. Some of them stated that their stay in SL will last until the expiration of their contract with Linden Lab, or until their projects stop being funded. Others stated that they are not intending to stop using SL, either because it is money, time and effort consuming to create their workspace from scratch within another VW, or because they have not yet found another VW as worthy as to replace SL. Contrary to them, some other educators stated that they are intending to replace or have already replaced SL with another VW or technology such as OS, OpenWonderland, Unity3D, Blue Mars and Active Worlds. Finally, the view that if Linden Labs keeps following their strategy of not supporting education, educators will opt to continue without the use of VWs, was expressed, as well.

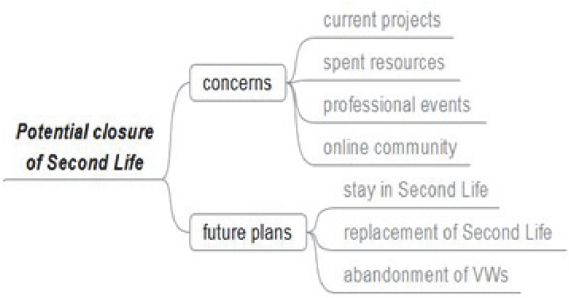

Figure 1: Educators' views for the potential closure of Second Life.

Nonetheless, at this point it should be noted that it is rather the high cost of using SL that affected educators in making these decisions.

4.2 The Educational Potentials in OS

The participants stressed that the OS technology has been significantly improved in the recent years. The competition with other well-established VWs had a positive effect on improving its stability, its reliability, and its interoperability. Nevertheless, this competition has a negative effect on its evolution too. The OS worlds have online communities narrower than SL, and given that it is open-source software, its upgrading may be slow, since it depends on the involvement of its own community, rather than a company's. It was also suggested that competition has no impact on the evolution of OS, as it provides services very different from other worlds.

During the interviews, the importance of backups for the persistence of OS worlds was also highlighted. More precisely, it was stated that it is very useful for cases where the workspace retrieval is considered necessary. In these cases, the educator keeps a backup of the world when it is in a desired state, introduces students to the world so as to carry out their activities, and then uses the backup file, in order to “regularize” the world and bring it back to its previous state. The same technique can be used in cases where technical issues that affect the smooth conduct of activities arise. Other educators reported that they use the backups in order to transfer to other servers and share with other educators objects, tools or even their entire workspace.

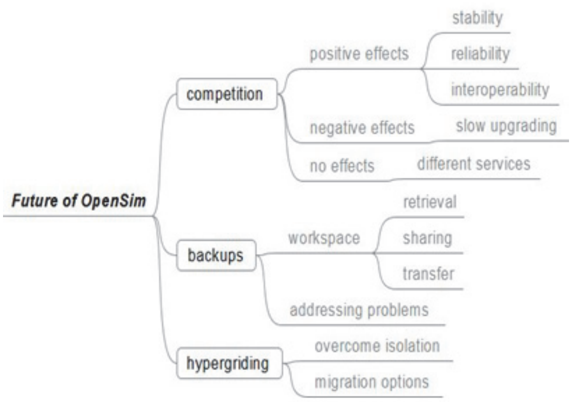

Figure 2: Educators' views about the future of OpenSim.

Finally, the interviewees’ view of the hypergriding potential was very positive, even though some of them seemed never to have used it. It is thought that hypergriding contributes to the overcoming of the isolation that is likely to occur in OSIHs or in worlds with a very small community. Consequently, interuniversity communication and collaboration can be achieved. Students have the opportunity to see the creations of others, and this may be an inspiration for them, making that way the lesson more interesting. Beyond these, it was reported that migration options are given to universities, and therefore a training group or the entire university can carry out their activities in another OS world, any time and for any reason.

4.3 Discussion

It seems, overall, that whether and for how long SL will persist depends purely on Linden Lab. Therefore, educators have to accept the decisions of the enterprise and then decide about their future plans. On the contrary, the persistence of the OS worlds depends on the aims and plans of the educators.

5 FINDINGS AND DISCUSSION

In conclusion, each VW has different advantages in terms of utility costs, while each can cover different needs. Specifically, SL is the ideal choice for those educators seeking a more time and effort effective option, or for educators who cannot devote much of their time for the preparation of the educational activities, or even for those who do not have enough knowledge on building and scripting to create the virtual space in accordance with their teaching needs. This is actually the case because of the existing wide marketplace in SL where educators can buy various items ready for use. Furthermore, there are many builders and scripters working in SL, able to offer their services to anyone upon payment. Additionally, educators often resort to the solution of “workspace sharing” or “items sharing” within the VWs, and are greatly facilitated by the fact that SL has a very wide community. Nonetheless, universities that face a decision to use SL for educational purposes should be prepared to pay high enough monthly fees for the rental of the virtual land, and they should also be aware that additional charges apply on the uploading of files and the use of more primitives than those granted along with the purchase of the land.

Exactly the opposite applies in the case of OSIHs. This choice is ideal for the universities which seek the most cost-effective option, but a basic prerequisite for this is the existence of proper infrastructure and qualified personnel which is able to spend time and effort to set up, maintain and ensure the server’s proper operation, and which is also able to build and script for the creation of the needed in-world facilities for the educational activities. Therefore, even though the economic cost of this option for the university is minimal, it cannot be considered as time and effort effective. Nevertheless, the required effort by the university staff can be significantly reduced, if these actions are assigned to students as part of their internship. It is also worth mentioning that the OSIHs are an ideal choice in cases where the main purpose of the in-world sessions is to allow students to build and script. In these cases, on one hand both the effort and time which has to be devoted by the university staff for the preparation of the in-world spaces is reduced, while on the other hand students can freely “play around” with the space, since there are no restrictions similar to those that occur in SL regarding the amount of objects and scripts. Moreover, the “workspace sharing” and “objects sharing” mentioned in SL also apply in the OSIHs, even in a different way than that of SL, since the backup files which are parts of the OS technology can be run in any OS server. Thus, the workspace created by a university can be copied and given for use to another university. Obviously, this is a highly money, time and effort effective practice.

Finally, choosing an OSDP is the “middle ground” between SL and OSIHs. Even though the university has to pay monthly fees for the provider’s services, the land fees of dedicated providers are considerably lower compared to the fees charged by Linden Lab for SL. Furthermore, unlike Linden Lab, the providers offer, from the beginning, the maximum number of primitives which can be used in each piece of land, while their cost is included in the monthly land fees. Therefore, similarly to the OSIHs, this option is also very suitable for building and scripting activities.

An apparent disadvantage of OSDPs, compared to SL, is the lack of a marketplace which helps educators to save effort and time. However, the “workspace and objects sharing” practice applies in OSDPs as well, as described both in the case of SL, i.e. the temporary use of the in-world facilities from other universities, and in the case of OSIHs, i.e. the backup files exchanging. Besides, there are no additional charges for files uploading.

Therefore, it seems that the case of OSDPs gathers many of the advantages –in terms of cost– that the other two solutions have, but it also shares few of their disadvantages, as well. It seems to have the lowest cost in terms of money, time and effort, if seen in total, but which one is the most “cost-effective” choice clearly depends on the needs and capabilities of each university.

Regarding persistence, the educational community appears to be very disappointed with the overall current situation in SL and some educators have already dropped out of it, choosing to use other VWs, even though it keeps operating. Therefore, the question is “for how long the educational community will be present within SL?”, or, in other words, “for how long will SL worth being used as an educational tool?”, rather than “for how long will SL persist?”. Regarding these questions, the views of the educational community members vary. A part of them still sees SL as a very convenient educational tool. Some consider it appropriate under certain circumstances, while others believe that education in SL has no future.

The advantage of OS regarding its persistence is that it is a technology for the creation of VWs, which is not supported by an enterprise, but by the open source community. Therefore, the persistence of OS depends on the choices of individual educators or universities. However, even if an educator opts to use the services of an OS provider, there is always the potential of transferring the activities to the server of another provider, or a private server, if it is deemed necessary, using backups and the hypergrid architecture.

This leads to the conclusion that educators who wish to obtain the widest possible control of the persistence of their world should opt to use either an OSIH or an OSDP. In cases where the long-term persistence of the world is not a major concern for educators, they may use SL, if they think that its benefits are essential for their projects.

In summary it can be seen that the extrinsic view is a matter of concern of educators using SL and OS. Given the SL issues concerning a possible closure (persistence) or increased costs a move towards OS based solutions is tempting and in many cases indeed has happened. Our findings seem to suggest that – unless Linden Lab positions itself clearly concerning their long-term SL strategy, in particular towards educators – this shift towards OS will continue as educators are more and more willing to accept a loss of the intrinsic dimensions of context and (possibly) immersion in order to get reassurance and a perspective concerning the extrinsic dimensions cost and persistence.

6 POSITION & PERSPECTIVE

Following from the above the University of Bedfordshire is hosting their activities now on their own OSIH (after extensive experience with SL and OSDPs in previous years). The virtual world is used to teach LSL as an event driven programming language and to foster activities of students learning Project Management.

The control provided within an OSIH is an advantage not only in providing an environment for students but also to analyse their activities as part of ongoing research.

Nevertheless to create the ‘look and feel’ of a true virtual ‘world’ we are now actively seeking collaboration to join educational virtual worlds as part of a hypergrid. The technology is readily available and it is our belief that seamless utilisation of virtual worlds across educational institutions will create a persistent and cost efficient virtual environment in which educational activities can be made available.

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The Impact of High Dropout Rates in a Large Public Brazilian University
A Quantitative Approach Using Educational Data Mining

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Keywords: Educational Data Mining, Dropout Rate, Data Mining, Databases, Algorithms.

Abstract: This paper uses educational data mining techniques to identify the variables that can help educational managers to detect students that present low performance or are in risk to dropout their undergraduate education. We investigated real world academic data of students of the largest Public Federal Brazilian University. We established three categories of students with different academic trajectory in order to investigate their performance and the dropout rates. This study shows that even analyzing three different classes of 14.000 students it was possible to have a global precision above 80% for several classification algorithms. The results of Naïve Bayes model were used to support the quantitative analysis. In this work, we stress that even few differences between the three classes of students that can be perceived on the basis of qualitative information.

1 INTRODUCTION

Brazilians agree that the Public Federal Brazilian Universities (PFBU) high dropout rates require urgent solutions as do the appallingly low levels of work readiness for a large number of people. Even educators, educational managers and policy makers agree that the Educational System is in desperate need of reform.

Every year the educational system offers an increasing number of seats in the public universities. This is motivated by the necessity to prepare large quantities of workers for engaging in the Brazilian emerging economy. It is a nation with social or business activity in the process of rapid growth and industrialization. The students who quit of higher education or take a long time to finish their undergraduate courses are considered part of a bigger problem that occurs in many PFBU.

Usually, PFBU offer the best quality education and are 100% financed by the federal government. Thus, to be admitted in a public university is an expectation of the most part of young people. However, the large amount of students which do not complete it represent an elevated cost without return to the government, society and institutions. For instance, the government misuse lots of public money to maintain professors, employers, equipments, laboratories, libraries and empty classrooms, the students have their future professional career diminished, and the growth of the companies is restricted due to the lack of skilled professionals in the labor market. Last but not least, many students dream of earning a degree that will help them secure a job. Many of them, however, will not see that dream come true.

The deep comprehension about the motivation behind the phenomenon of dropout is complex. Several studies have been realized to detect the causes of high dropout rates in Brazilian educational system (Soares, 2006) and (Lobo, 2011). There are some explanation that tries to elucidate such phenomenon: (i) difficulties to adapt to the academic environment; (ii) difficulties to attend the courses; (iii) poor academic background; (iv) lack of parental support or (v) the needs of balancing long hours of labour and study, just to name a few.

This paper uses Educational Data Mining (EDM) techniques in the context of searching and extracting relevant information from the already existing PFBU databases. In this study, the real-world records were extracted from the academic management system of Universidade Federal do Rio de Janeiro (UFRJ), the largest PFBU.

In order to investigate the high rates, we defined three categories of possible student academic trajectory: (i) *dropout,* (ii) *still-enrolled* and (iii) *completer*. The term *dropout* was awarded to all students with enrolment status (registration) cancelled by: (1) student initiative: cancellation of the registration in an undergraduate course; or (2) institution initiative: registration cancelled for abandonment of the undergraduate course, failure to complete curriculum requirements and others disciplinary actions. The term *still-enrolled* (*non-completer*) was awarded to all students who are still enrolled, but present slow progress to achieve their completion. Finally, the last term, *completer* was awarded to all students who have fulfilled all the requirements of the curriculum and obtained their degrees.

We investigated the key factors about poor student´s performance that are important to determine and to identify the three groups that can get success or fail in get their degrees. Those characteristics of restriction represent a multi-class problem. However, not all data mining algorithms can evaluate a three-class problem. Thus, in order to circunvent such issue we evaluated several EDM algorithms and applied them to the records extracted from the academic management system of UFRJ.

This paper is organized as follows. In Section 2, related works are presented. Section 3 presents our approach. In Section 4 presents a case study at UFRJ. In Section 5 summarizes, the final considerations and presents future works.

2 RELATED WORKS

In this section, we discuss previous works that investigated the student dropout and performance prediction using EDM techniques. At this time, there are several definitions of the term dropout in the literature and how to measure its rates. Likewise, the meaning for still-enrolled or non-completers (unfinished degrees). Before, starting discussing the EDM related works; we assume that it is necessary to define the terms used in this paper. We adopted the same conceptualization used by the Brazilian Ministry of Education to guide our work. It is assumed that *undergraduate course* (undergraduate programs) refers to the entire program (or curriculum) of studies required to get a higher degree. The term *course* refers to a unit of instruction offered during the semester or academic year to compose an undergraduate course. Some works (Lykourentzou, 2009) and (Huang, 2011) consider the term dropout when the student abandons the course, for us the term dropout is used to classify the student who fails to complete, abandon or withdrawn their undergraduate course.

Some PFBU have already investigated dropout measuring in it singular ways, and many of them confirmed that non-completers could be strong candidates to dropout (MEC, 1997), (Soares, 2006) and (Lobo, 2011). Therefore, those previous works considered different perspectives than ours: (i) socioeconomic reasons (keep a job to live or to support the family; the influence of the family); (ii) vocational reasons (disappointment with erroneous course choices); and (iii) academic reasons (failure in initial courses, poor academic background, difficulties in professor relationships or with colleagues). However, the analysis of reasons (i) and (ii) are multifaceted due to the student data available. In turn, some features of item (iii) are based on the information stored in Academic Management System of the universities.

EDM is an emerging discipline used to handle huge amounts of educational data spread across many datasets. With regard to educational databases, Baker and Yacef (2009) presented EDM as concerned with developing, researching, and applying computerized methods to detect patterns in large collections of educational data that would otherwise be hard or impossible to analyze due to the enormous volume of data. Indeed, EDM is a new approach to support educators, students, academic manager, governments and society to take advantage of such knowledge (Baker, 2009, 2011) and (Romero, 2010, 2013).

Kotsiantis et al. (2003) work was focused on the prediction of student´s dropout in undergraduate courses at Hellenic Open University. The authors analyzed the undergraduate course of "Informatics" but considered a single online course "Introduction in Informatics". Such work compared six data mining techniques. The authors asserted that the Naïve Bayes algorithm was the most appropriate and their conclusions could be widespread in the majority of distance education curriculum in the university.

Dekker (2009) investigated the Electrical Engineering undergraduate course at the Eindhoven University of Technology. Such study considered the data collect from 2000 to 2009 from no more than 648 students in the first year of their undergraduate course. The author considered the results of data mining techniques, and the overall results shown decision tree algorithms as more suitable for solving the problem. Pal (2012) predicted the dropout of engineering students solely of the first academic year. This research used four data mining algorithms, but the emphasis was in the analysis of the student data.

The above mentioned works are focused in predicting student dropout in a particular undergraduate course. In (Lykourentzou, 2009) and (Huang, 2011) the research was in the context of a specific course. Those works share similarities, such as (i) they identify and compare algorithm´s performance in order to find the most relevant EDM to solve the problem, or (ii) they identify the relevant attributes associated with the problem of dropout.

As far as we are concerned, the key differences from such related studies to our approach are the following: (i) in our case, the number of samples used to construct the subsets for applying EDM is significantly higher than those works; (ii) the number of student classes involved in our case was also bigger; (iii) in our study, all undergraduate courses of the largest Brazilian PFBU were analysed, and (iv) we describe a quantitative approach based on the prediction of EDM algorithm. Therefore, we identify three different classes of students that are aligned to common Brazilian context: (i) *dropout,* (ii) *still-enrolled* and (iii) *completer*. That classification is based on student's progress to complete academic requirements toward completion. In addition, we create graphics to represent clearly the students' features obtained by NaïveBayes classifier. The analysis evaluated the performance of the students during 12 semesters since their enrolment in the University. Besides, we took into account each of the following semesters and the distinct classes that the students have attended.

3 THE PROPOSED APPROACH

High rates of dropping out are issues continually debated. However, there are few systems that can analyze the problem and identify the dropout in advance or still-enrolled (non-completers) students.

Our approach uses techniques to identify and to evaluate several factors that occur during the student academic trajectory. The observation of the performance of the student in every academic semester represents a particular research to EDM due to the possibilities of find interesting information from data collected during a long period of time. The EDM algorithms must have good accuracy and to yield interpretable results. The information obtained after the EDM process may allow academic managers to trace the main factors that define more narrowly the activities of students and their expectations to complete their undergraduate courses.

Our approach have three goals: (i) evaluate the attributes available and identified those that describes the student performance; (ii) testing EDM algorithms and comparing their accuracy using a three-class problem, and (iii) finally, present a quantitative approach of the main observed factors using the results of most accurate and interpretable algorithm.

3.1 Description of Dataset

The pre-processing phase of student data must be executed before the application of EDM techniques. However, the availability of data is restricted and selecting the key attributes is a hard job and time consuming task. In our study, we did not adopt the use of non-academic information because was out of the scope of this study to collect non-academic information for all students of UFRJ. Other authors used non-academic data, but there is a lack of information in the literature about the adequate data for predicting the academic student performance. Indeed, we emphasize that all of the student data analyzed in this study was provided by the Academic Management System of UFRJ.

The following attributes were considered: anonymized student identification (id), undergraduate course id, year and semester of admission, undergraduate course status, CGPA (is a calculation of the average of all cumulative student's grades for all courses completed in years of study). The attributes for the semester are: semester id, status of the semester id, GPA (it is the average took in the current semester). We also considered several attributes about the student enrolled in the courses of a semester, such as course id, number of credits, the numeric grade and an alphanumeric grade (course final situation: approved, failed, absence).

3.2 Selection of Attributes to EDM

The dataset were not ready to be directly used by the EDM algorithms. Thus, we conducted many experiments to define the necessary transformation rules for deriving the best attributes values. Those initial data transformation experiments were executed and discussed in a previous work presented by our research group (Manhães, 2012). Several new attributes are considered in this work, for instance, (1) student id is the key to identify the student in the datasets; (2) semester id is used to identify the data of the semester; (3) a novel attribute to store the number of courses in which a given student is enrolled in the semester; (4) number of courses approved in the semester; (5) the average grade of the approved courses; (6) number of course, in which the student fails due to absence or low grade; (7) number of course that the student failed due to low grade; (8) GPA; (9) semester enrolment status; (10) CGPA; and (11) undergraduate course status, it is used as a class label attribute. Such attribute has three values that describe the final state of the student enrolment: dropout, still-enrolled (non-completer) and completer.

3.3 EDM Techniques

In this work, we select the classifier algorithms for dealing with a multi-classes problem. Besides, we considered the accuracy and interpretability model of well known and more frequent classifiers algorithms used in data mining. We compared five Weka classifiers: decision tree J48 (C-4.5) and SimpleCart, Support Vector Machine (SVM), probabilistic model (Naïve Bayes), and neural network (Multilayer Perceptron - MP).

4 A CASE STUDY AT UFRJ

In this work, we have investigated the student admissions since the first semester of enrolment at the UFRJ over the period 2003 to 2004. We selected all records about individual student´s academic trajectory in each semester from 12 semesters after first enrolment (up to 2010-2). Our database includes 155 different undergraduate courses offered by 28 distinct departments of UFRJ. The Table 1 illustrates the number of student divided into three-classes established in this study.

Table 1: The number of first year students.

Admission Y/S	Dropout	Still-enrolled	Completer	Total
2003-1	1448	365	1995	3808
2003-2	1204	342	1494	3040
2004-1	1733	605	1900	4238
2004-2	1255	616	1280	3151

Due to the limit of space, we present only the results details obtained to the database of students who were first year enrolled in 2003-1. Another requirement to apply data mining classification algorithms is the division of the database, in this case study, we chose k-fold cross-validation with the number of sets equal to 10 (k = 10), due to the large number of samples available in the database. Table 2 presents the results of five classifier algorithms over the databases identified by student admission in a year/semester (2003-1).

Table 2: The classifiers, accuracy, the confusion matrix and True Positive (TP) rate. In the confusion matrix, the following labels are used for the classes (a) dropout, (b) still-enrolled and (c) completer.

Classifier	Accuracy	Confusion Matrix a	b	c	TP Rate
J48 (C4.5)	82.77 %	1172	68	208	0,809
		67	126	172	0,345
		84	57	1854	0,929
SimpleCart	83.90 %	1179	59	210	0,814
		52	165	148	0,452
		72	72	1851	0,928
SVM	87.39 %	1249	64	135	0,863
		77	184	104	0,504
		51	49	1895	0,950
Naïve Bayes	79.59 %	1079	150	219	0,745
		27	243	95	0,666
		38	248	1709	0,857
Multilayer Perceptron	85.34%	1190	64	194	0,822
		58	155	152	0,425
		36	54	1905	0,955

The classifiers differ from each other in the run time (in seconds) to build one model: J48 (0.89), SimpleCart (29.11), SVM (15.85), Naïve Bayes (0.13) and MP (4607.21). The more sophisticated algorithms require longer times to build models. Otherwise, more simple algorithms lose a little bit in the accuracy of the model. The accuracy and TP rates showed a suitable classification models for all algorithms when applied to the three classes of students. The results presents in table 2 are very similar for other databases 2003-2, 2004-1 and 2004-2 (Table 1).

4.1 EDM Quantitative Approach

In this paper, we analyzed the academic trajectory of about 14.000 students at UFRJ. We investigated 12 academic semesters from the first student enrolment. In this period, it was possible to observe and compare the features of the three class of student. Although, the Naïve Bayes classifier has not presented the best accuracy when compared to other algorithms, its overall performance meets the objectives of this work. The model generated by the algorithm is easier to be interpreted by humans and adapted to the process of data visualization.

Our quantitative approach was based on the results obtained with Naïve Bayes classifier; that information was converted in graphs. The following graphs show in the x-axis a time interval (semesters) from 2003-1 to 2008-2, and a colour legend identifying the three classes of students (dropout, still-enrolled, completer).

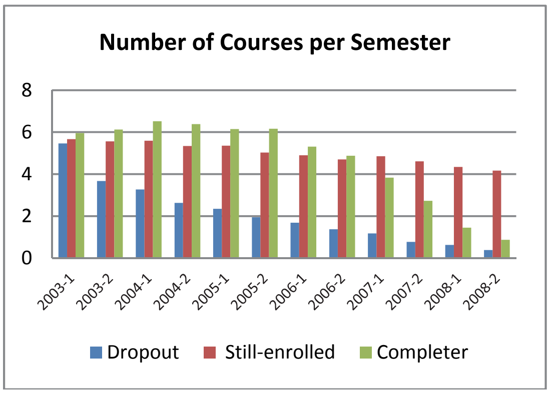

Figure 1: Number of courses registration in each semester.

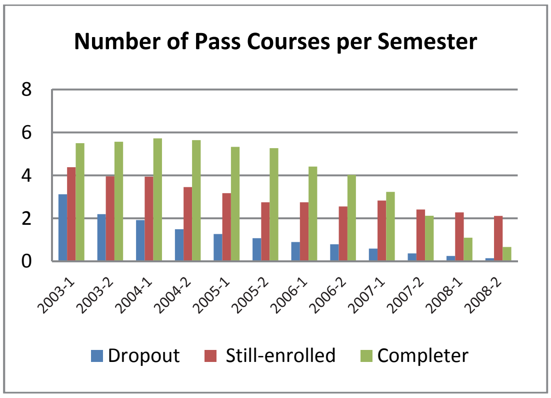

Figure 2: Number of courses with passing grade.

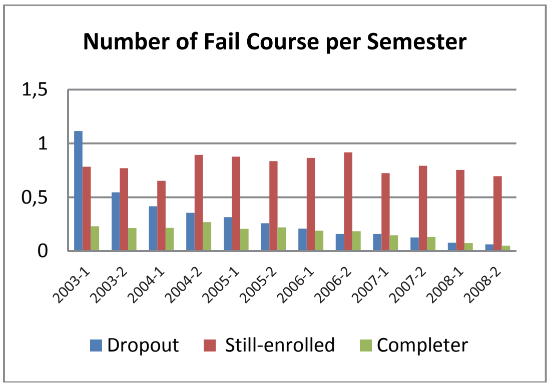

Figure 3: Number of courses with failing grade.

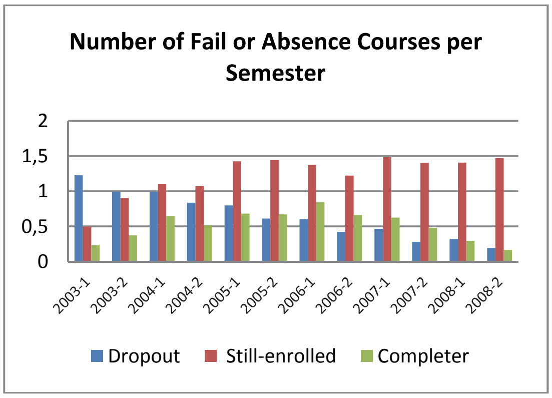

Figure 4: Number of courses with fail or absent fail grade.

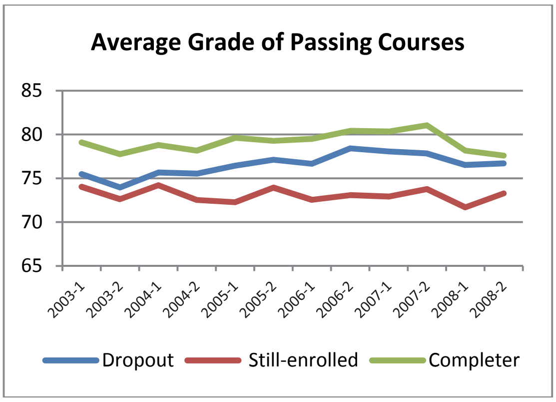

Figure 5: Average grade of passing courses.

4.2 Analysis of the Results

As described in Table 1, the database comprises a significant number of samples for each subset of student. Due to space reasons, we present the results for 3.808 students that were admitted in the first semester of 2003 (2003-1). However, the same EDM procedures described above were done with students which were admitted in three consecutive semesters, 2003-2, 2004-1 and 2004-2. The results obtained were very similar to those found in the 2003-1database.

We summarized the most relevant features concerned with the three classes of students analyzed. The figure 1 shows that, in the first semester, all the students are enrolled at about 5 to 7 courses; it depends on the undergraduate grading scheme.

It was observed that students that quit the studies at UFRJ present the following features: (1) they reduced the courses enrolment in each semester until withdraw; (2) they have a decreasing number of courses with passing grades in each semester; (3) they have at least one course with fail grade in the first academic semester; (4) they have at least one course with fail or absent fail (AF) grading in the first academic semester; (5) at the end of the first semester, the students who give up had the average grades of passing courses lower than completers, and finally, (6) comparing Figure 1 and Figure 2, the student who dropped out have a good grade about (74-78), but in very few courses.

With respect of the still-enrolled students that were observed in the investigated subset. We observed that they maintained their enrolment active by the year/semester of 2009-1. They have the following features: (1) they are enrolled at about 5 courses during the undergraduate course; (2) they decrease the number of passing course in each semester; it is less than completers students but higher than the ones who quit; (3) during the semesters, they have higher possibilities of failing a course, compared to others classes of students, and finally, (4) in the first semesters they have less than one course with fail or AF grading, in the following semesters the number of course is above one; (5) the average of grade of passing courses is the lowest comparing with two other classes.

With regard to students who complete the course, they have the following features: (1) maintain a high number of courses enrolment in each semester; (2) have a high rate of pass courses; (3) the number of fail courses is close to zero throughout during the stay in the university; (4) the average of courses with fail and AF grading is less than one; (5) maintain the average of pass courses close to the value of the CGPA until the 8th semester of the degree. Students who completed the degree present a regular behaviour throughout all semesters; they enrolled in a high number of courses and got high average passing grades.

5 CONCLUSIONS

This paper compared five classification algorithms; the results allowed us to investigate a three-class problem related to the situation of the students of the largest Brazilian PFBU. The SVM algorithm was unfeasible to be used because the time spent to construct the model was too high. The algorithm Naïve Bayes has an interpretable model and its numerical results can easily be converted into graphs. In this paper, we presented a quantitative approach using the results of such algorithm. The quality of the results opens the novel possibilities of further investigations, the development of an information system capable of facilitating the management of academic universities. The direct benefits of applying data mining in this context are: (i) identify the course students more likely to dropout and still-enrolled students; (ii) allow the FPBU to use not only statistical analysis of facing the problem of high dropout rate.

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Meeting the Demands of the 21st Learner

Delivering Elementary Science and Math Methods Courses Online an Auto-ethnographic Approach

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Keywords: Online Learning, Teacher Education, Hybrid Courses, Challenges in Teaching, Autoethographic Methods, Teaching Strategies.

Abstract: In the last two decades, online enrollment in higher education has increased substantially. As more students enroll in courses, Universities may find that the demand within the institution will grow beyond current offerings. Within the field of teacher education, hundreds of online course offerings in teacher preparation programs worldwide are offered. The advantages to online versus face-to-face courses are numerous. Despite the marked increase in online course offerings and enrollment, however, some obstacles do exist in online classes. A review of recent literature indicated a need to study the challenges faced by faculty who teach hybrid courses and the need to better understand what constitutes quality online education. So, the importance of this research is how do teacher preparation programs meet the demands and charges of institutions while maintaining quality of instruction. Using autoethographic methods, two professors who teach elementary science methods and elementary math methods chronicle how they begin to address the challenges in online teaching and how they overcame those challenges to meet the needs of the 21st century learner. The participants in this study describe how they apply constructivist concepts solely online. These outcomes are what we call the call the good, the bad and the ugly.

1 INTRODUCTION

With the pressures of teaching online, it is important to consider faculty's perspectives on teaching in this environment. One way to understand how faculty members experience online teaching is by having faculty members' reconstruct experiences, and elaborating on the meaning that they assign to those experiences. The two participants in this study while have the same objectives, providing a quality online course; are intentional in the assignments given to students as a way to achieve similar but different objectives. For example, Cleveland with a background in social justice education his narrative is grounded in the 8 essentials for empowered teaching in learning. As a former public school science teacher, he knows that science is a gatekeeper who often keeps ethnic minority, the poor and girls locked out of the gate and he wants his students to be able to give their students the keys to that gage. Conversely, Andy's outcome is to lower the affect of teaching math.

The purpose of this paper, using autoethnographic methods two faculty members at a small liberal arts college describe how they meet the above objectives and others in a methods course taught solely on line. These outcomes are what we call the call the good, the bad and the ugly.

2 LITERATURE REVIEW

Online education is defined as a platform for delivering educational content and facilitating instructor-student interaction over a computer network (Shelton and Saltsman, 2005). Online courses are available anytime and anyplace and learning is interactive and collaborative. Students and instructors share discoveries throughout each step of the course. Many online courses use a combination of delivery modes including a variety of technologies.

Many faculty members in higher education have been asked to teach online. While online education has become routine with 65% of graduate programs across the country using the Internet to deliver classes (Norton and Hathaway, 2008), many colleges and universities are still struggling to discover how to provide a quality educational experience. For students, the virtual classroom provides unlimited access to course material, including resources, virtual manipulatives, lecture notes, and even video or audio recordings of lectures (Owen, 2010). For the instructor, however many cast a skeptical eye on the learning outcomes for online education. Allen, Seaman, Lederman and Jaschik (2012) reported that nearly two-thirds say they believe that the learning outcomes for an online course are inferior or somewhat inferior to those for a comparable face-to-face course. Most of the remaining faculty members report that the two have comparable outcomes. Even among those with a strong vested interest in online education – faculty members who are currently teaching online courses – considerable concern remains about the quality of the learning outcomes.

Dziuban et al. (2005) found that faculty perceptions regarding student learning in a hybrid courses were very satisfying and that student learning and performance is equal to or better than traditional face-to-face course settings.

3 THEORITICAL FRAMEWORK

As a framework for designing constructivist learning environments, Jonassen and Rohrer-Murphy (1999) postulate that conscious learning emerges from activity (performance), not as a precursor to it. Engestrom (in Jonassen and Rohrer-Murphy 1999, 72–77) lists six steps when designing learning experiences. These are: 1) clarify the purpose of the activity system (what are students' goals, motives and expectations?); 2) analyze the activity system (for example the student as subject, the community in which the subject works, the outcomes that need to be achieved); 3) analyze the activity (such as problem-solving actions); 4) analyze tools and mediators (such as methods, language, forms of work organization); 5) analyze the context (the real-life, non-instructional contexts within which activities occur); and 6) analyze activity system dynamics (this requires a final assessment of how all the components affect one another).

Bruner's (1990) Constructivist theory has been adopted and utilized for many different instructional situations. The online classrooms can incorporate Bruner's theory of Constructivism in a number of ways. Discovery Learning is one way that Science teachers can make use of the theory since the theory itself is somewhat close to scientific inquiry. Similarly, Pais (1997) noted that the constructivist framework for mathematics education makes prominent the notion that each learner must actively construct her/his own mathematical concepts and that, ultimately, mathematical knowledge consists in the learner's individual ability to do mathematics in a given context, by purposefully re-constructing useful mathematical concepts and tools appropriate to the given context. Teachers have to communicate how to do mathematical operations to students so that they understand. The Constructivist approach requires that each learner actively construct their own internal concepts into their mathematical schema.

4 METHODS

Reed-Danahay (1997) describes autoethnography as enlisting a rewriting of the social self. For the purpose of this research we are asking the questions, "What are triumphs and challenges of moving a course historically designed to be taught face-to-face to solely on line? A second research question would be how are we meeting the demands/needs of the 21st Century learner/student and the 21st Century student these pre-service teacher will eventually teach?

Quicke (2010) argues that autoethnographic work often involves, as is the case of this project, looking back and analyzing personal memoirs and is often focused on the self as participant in the social process. Autoethnographic accounts of experiences, by virtue of being self-reflective, are deeply personal and researchers using this still must produce a highly personalized revealing text in with an author tells stories about his or her own lived experiences.

Autoethnographic methods according to Douglas and Carless (2013) are centered on the various aspects of our lives. While these narratives can serve as models for others to reflect on their practice as described in the narratives. It is important that these narratives are individual and does not speak for other professor who teach methods course on line. But as well all stories we as a community of academics we can all learn for each other's stories and lived experiences (Douglas and Carless, 2013; du Perez, 2008; Leonardo, 2009).

Cleveland Hayes and Andy Steck are faculty members at a small private college in the American West. Several years ago the Dean of the College answered the Universities call to move as many of the College's program to totally on-line and /or hybrid were the course are taught as in the case of this department 70% face to face and 30% on line. Two of the authors of this paper were also tasked to provide our science and math methods courses totally on-line. Initially, we were both skeptical about teaching a methods course totally on line. The first question we asked ourselves was how are we going to create a constructivist classroom online. This translates to how do we provide pre-service teachers a constructivist experience on-line and in the case of one of the researchers how was he going to incorporate social justice curriculum into an online environment, because so much of social justice education depends on relationships between students, between students and the professor and between the content. This researcher sees teaching as a how to think process and less how to process and how too (Hayes et al., 2011). This was a challenge for Cleveland. Bottom line we have two different approaches to teaching methods course in general let alone in an online setting.

5 AUTO-ETHNOGRAPHIC APPROACH TO TEACHING ON-LINE

5.1 Cleveland

There are several themes that come out of my narrative. The more pressing theme is lowering the students' affect towards the science content as well as teaching science. As a former high school science teacher, I know that science is a gatekeeper. It is a gatekeeper because while it may open many opportunities not knowing the content is also a gate closer. As a gatekeeper it keeps students, especially those in poverty, from career opportunities that may get them out of poverty: careers in health care, science and engineering courses.

A second theme from my narrative is that by taking a class on line forces pre-service teachers to use the latest technology and Web 2.0 tools not only for their engagement in the curriculum but also as a means to engage their future students in the curricular. Because if as educators we are going to move students out of poverty, closing the digital divide through teaching a methods course online, provides opportunities for students to use the latest technology tools as a way to show their understanding of the science concepts. The way the students have to engage the material forces them to learn ways to close the digital divide as we know being educated is one way of getting students out of poverty and technology is one of those ways to help students out of poverty (Hayes et al., 2011).

5.2 Andy

Several themes emerge teaching a math methods class online. The first theme is the affect of teaching math. Another theme is changing the mindset of students to teaching math effectively versus the approach they learned from in their own experiences.

How do I as the instructor reduce math anxiety my students exhibit and endorse when they share their "stars and wishes" of their strengths and weaknesses in math as an initial assignment. I learn quickly the anxieties they share about teaching math. In the face-to-face class, learning to use a variety of manipulatives to understand math concepts prior to learning the procedural concepts greatly reduces the amount of anxiety. Students comment, "if only we used these when I was in elementary school my math skills would be stronger. The online challenge to use manipulatives is met through virtual manipulatives found on many websites, but this challenge is also met as students demonstrate their understanding and use of manipulatives through technology using Voice Thread, You Tube videos or Jings.

Changing the mindsets of students is a challenging feat in itself when an instructor meets face-to-face with students to initiate discussion, set with examples of how effective instruction can occur. To meet this challenge online, videos of classrooms must be analyzed, as are articles through the use of blogs and wiki discussions in class. To show an understanding of how effective instruction is internalized, one assignment is to have students in the course create word problems online, solicit responses from students at the appropriate grade level and analyze the various approaches used to complete the word problems. A reflective piece is written as a response to the analysis. Students must begin to understand there are a variety of procedural skills, which can be developed and used to solve problems, versus the one procedure they learned themselves.

6 CONCLUSIONS

Through the use of autoethnographic methods, this paper responds to 1) the challenges faced by faculty who teach hybrid courses and 2) the need to better understand what constitutes quality online education. This research with two professors who teach elementary science and math methods and how they begin to address the challenges and how they overcame those challenges to meet the needs of the 21st century learner. In our classes we have both traditional undergraduate student and adult learners from our universities program geared towards working adults and the unique set of challenges they bring. Through our narratives we are self-reflective on how we struggled and in many cases overcame the challenges finding ways to deliver quality distance education.

There is a growing body of literature that addresses what students identify as challenges in distance education (Hughes, 2007; Hilgenberg and Tolone, 2000; Chen et al., 2007; O'Malley and McCraw, 1999). However, there is not the same level of research about what instructors believe and their perceptions, concerns and challenges teaching in the online classroom. Interest in online learning will continue to grow as more and more students experience online courses (Brown and Corkill, 2007). As more students enroll in courses, Universities may find that the demand within the institution will grow beyond current offerings. So, the importance of this research is how do teacher preparation programs meet the demands and charges of institutions while maintaining quality of instruction.

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The Values on Academic Frontier-based Approach' Implementation

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Keywords: Academic Frontier-based Approach, Implementation, Gain, Difficulties, Suggestions.

Abstract: Academic Frontier-based Approach (AFA) is a student-centred instructional approach used to promote active and deep learning by involving students in investigating academic frontier issues in a collaborative environment. In this paper, we discuss the student surveys conducted at the end of the study period to solicit feedback from students on their learning experience. It is suggested that AFA takes the students as the center, consolidates the academic knowledge of the students. Through the teamwork and autonomous learning, students know more about the frontiers of science and technology and open their horizon. In addition, the ability of language organization, speech, compressive resistance, communication and cooperation are all increased. Furthermore, students' interest in studying is increased because of the autonomous learning. It is expected the popularization of the consecutive courses will certainly improve these important abilities further more. And it is hopeful that students will take advantage from the sustainable ability of autonomous learning in their future career life.

1 INTRODUCTION

As one of the Student-centered teaching methods, collaborative learning activities can provide students with the opportunity to study for them, conduct small research projects and foster their higher level cognitive thinking skills. Johnson and Johnson's model of cooperative learning highlighted five essential elements: positive interdependence, promotive interaction, individual accountability, group processing, and social skills (Johnson, 1984). The social-constructivist methodology for collaboration was first proposed by Kiraly (Kiraly, 1995). From Kiraly's view point (Kiraly, 2000), collaborative learning (CL) emphasize its joint completion so that the team members can construct meanings together and can develop cultural and professional knowledge. Obviously, CL, which characteriser student-centered teaching method, represents a significant shift away from the typical lecture-centered milieu in higher education. According to Kiraly, there is an evolution from teaching oriented towards the teacher as the main source of knowledge to teaching based not on the students themselves, but on teaching itself. In the learning activities, students generate social interaction among the team members and mutual dependence to achieve specific aims (Johnson, 1994). In collaborative classrooms, teachers who use collaborative learning approaches tend to think of themselves less as transmitters of knowledge. On the contrary, they act as instructors in the learning process. Therefore, it is important to design teaching strategies that not only go beyond the content in textbook but also along the theme of the knowledge in it.

In the paper, what we concern is achieving better student learning outcomes by Academic Frontier-based Approach **(AFA)** that centers students' learning in collaborative learning.

2 ACADEMIC FRONTIER APPROACH IN COLLABORATIVE LEARNING

Academic Frontier-based Approach (AFA) (Liu, 2013; Liu, 2013; Liu, 2014) is an approach to achieve the new learning outcomes of courses related to the content in textbooks — expansive

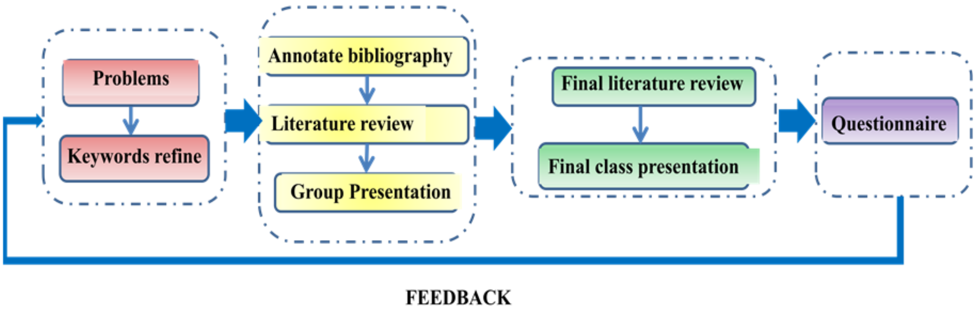

Figure 1: The implementation of AFA.

learning. In order to keep courses content up-to-date and build the intellectual curious and inquiring mind that characterize good academic motivation for learners, we developed Academic Frontier-based Approach (AFA) in collaborative learning.

Its implementation includes four basic steps: (1)Instructors propose questions from textbook, then refine keywords related to the development of subject; (2)group work and (3)team work are conducted; (4)Questionnaire for the purpose of feedback to improve the teaching. Obviously, the implementation of AFA in collaborative learning is a cognitive constructivist epistemology which concludes from science literatures that learners gain more through relating academic material and papers to their own interests and academic vision, and that such experience informs their ability to conceptualize content (Duffy, 1992; Jonassen, 1949).

3 THE VALUES FROM STUDENTS' SURVEY ON AFA IMPLEMENTATION

3.1 Consolidation of Academic Knowledge, More Contact with Frontiers of Science and Technology and Open Horizon

Through the presentation of each group, students can get to many interesting branches of subjects and fields of scientific research, know forefront of many scientific information and broaden their horizon. Besides, they will have a better understanding about their own major and practical application of that. They can learn the newest knowledge automatically, and expand their knowledge of semiconductor. On the one hand, students feel interested in learning. On the other hand, they enrich their knowledge, have better understanding of related knowledge and improved their professionalism. They can have a better understanding of things like graphene， carbon nanotube， organic semiconductor， SOI devices, the process of energy-band engineering, heterojunction and semiconductor of third generation.

3.2 Improvement of Comprehensive Ability

In the aspect of comprehensive ability, students have obvious improvement of organizational competence, speech, resistance to pressure, communication and operation. What AFA brings to students is what the traditional class which is centralized in teach cannot provide.

Because the speech time is limited within 5 minutes, the students' ability of summary and organizational competence as well as resistance to pressure will be improved. Students get to know each other more and deepen their friendship. And they will practice their ability of communicating and cooperation. Moreover, students will have more courage to stand in front of people to make a statement.

The skills of using modern office software will be greatly improved, such as making PPT. They will gain precious experience of making a presentation. Through looking up documents in all kinds of fields, students will have a fairly deep understanding about the topic. It is also a very good chance to improve eloquence, which is even better for those students who are introvert and seldom get on to the stage. Furthermore, student will clearly see their weakness and can get better through the experience.

3.3 The Ability of Looking up and Screening the Documents Independently

Students will learn how to find a certain needed

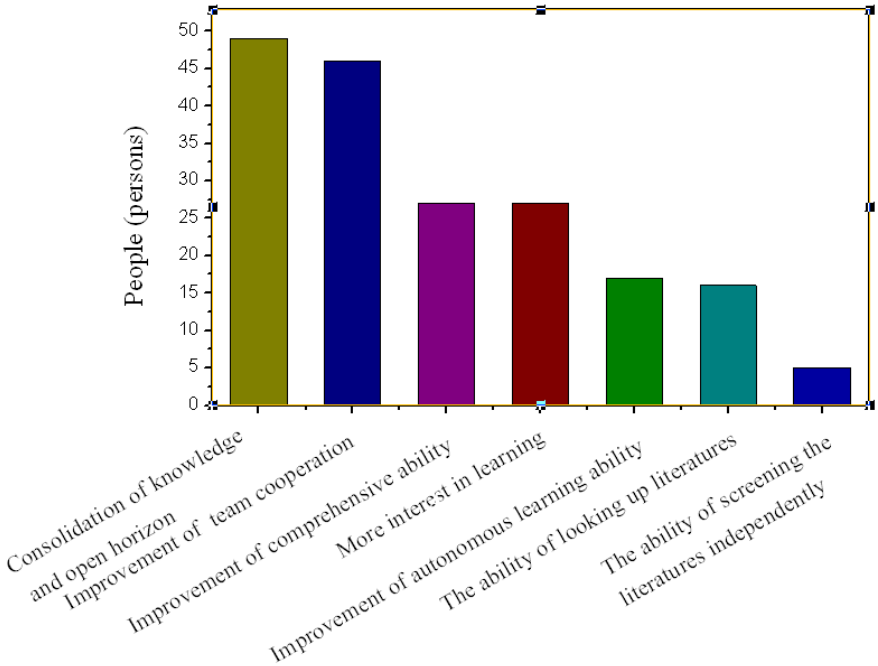

Figure 2: The students' Questionnaire survey.

document. Also they will master many ways to look up the newest materials. For example, student will make full use of the electric resources so that they strengthen their ability of looking up documents.

Students learn how to look up, read and screen a certain literature. Then they get the ability to find something they are interested in, so that they gain a good habit of learning beyond the textbook.

Students will improve their ability of finding and summarizing knowledge.

3.4 The Team Cooperation

Students can learn how to help each other, communicate and cooperate with the teammates. Through the teamwork and sharing, students form the awareness of teamwork so that their group cooperation and communication have improved.

3.5 More Interest in Learning

Their interest in semiconductor physics will be raised. "The key point is that the freedom brings plenty of interest." It is convenient for students to choose a certain field they are interested in and continue studying. They feel good about the presentation on the stage, so the class becomes more compelling for them. Thus, students will be more interested in the field of microelectronics; moreover, they can feel the fantasy of their major and raise the interest in scientific researches.

3.6 Improvement of Autonomous Learning Ability

As a result of interest rising, the individual initiative of learning is strengthened. The ability of self-studying is improved.

3.7 Getting the Key Points of a Paper Quickly.

Students will know how to read a newly paper and get brief view of a paper, and they should also learn the way to catch the key point of a paper.

3.8 The Difficulties in the Implementing Process of AFA

In the step of listing the difficulties freely, 'the difficulty of looking up documents and selecting the materials' is listed first. At the same time, students share experience according to their own experience, which shows the confidence to solve problems.

They lack the ability to look up English documents, the sensibility of the materials, the ability of caching useful information accurately and finding useful data quickly. The understanding of English documents needs improved, since students nearly have no idea what the English papers are talking about. To solve the problem of reading documents, reading more is the only way. Students should learn more key words of the major, master a certain proper way to read and practice as much as possible.

While choosing materials, students should start with small points and expand it later to more aspects. What really matters is not the quantity, but the quality. Also, students need to read more literature in the daily life to get access to the frontier knowledge, and when they encounter some literature which is strongly professional, they can deal with it more calmly.

Students do not have adequate preparation, and cannot arrange their time on the stage well. And it is also important to adjust the psychological states to face the problem of performance anxiety. Students need to take part in more implements, to prepare well before making the presentation. Practice always makes perfect.

It is important to have a comprehensive grasp of the topic and clear mind.

About the production of PPT. It is important to have a clear and concise content of PPT, instead of gorgeous appearance. Making more PPTs is a good way to promote the level of making PPT. PPT producing is a basic ability; students should master it and deal with problems by themselves.

Thus, speech time and the topic of the speech are two aspects that need improve. And direction that needs to be adjusted in the next step of education is listed.

3.9 The Questionnaire Survey--Suggestions for Improvement for AFA

Extending the speech time. Too short speech time cannot clarify the statement clearly, which reduce the quality of sharing. Although some students have a deep understanding about the topic, limited presentation time makes students just state some of the content in stead of all of them. This may result in decrease of audiences' understanding, because the basic content is skipped. For example, the students really want to share the alloy method, heterojunction method and the lattice strain method of energy band engineering when they introduce energy band engineering. However, considering 5 minutes' time for this part, they cannot elaborate it. Topic of the speech.

This kind of presentation should focus on stimulating the interest and increasing knowledge. So if students combine the topic with subjects that students may encounter in their graduate period, their enthusiasm will be improved and that can set a good basis for their further study.

Add the part of interaction. More interaction and more chances for audience to ask questions will help the audience understand the presentation better.

4 CONCLUSIONS

It is found that a few do not approve the aspects of autonomous learning ability and getting the key points of a paper quickly. First of all, it is the first time to be involved in such programs for students who take part in AFA. During the past four years, we chose 6 classes to implement the AFA program. For students used to the mode that takes teacher as the center, their ability of autonomous learning is expected to improve on the basis of rising interest. In the aspect of document reading, it is reasonable that not many students approve the achievement. Because for students who just begin academic English reading, lacking training will lead to the result that the difficulty of reading and understanding new knowledge will restrict each other. If we persist in implementing AFA, students' academic English will get better and that will bring promoting effect to them for in the future in some degree.

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UBIQUITOUS LEARNING

FULL PAPER

How to Design a Mobile Learning Environment
Recommendations Based on Student Perceptions

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Keywords: Mobile Learning Environment, Mobile Learning, User-centered Design, Mobile Strategy.

Abstract: The rise in sales of smartphones, the importance of anywhere connectivity, the general adoption of mobile apps, and the opportunities brought by mobile devices in educational settings underline the delay with which universities have moved to adapt their virtual learning environments for mobile devices. Providing students with a means to access the learning environment from a mobile device is therefore a pressing need. In this paper we present a series of recommendations designed to guide universities in the development of mobile learning environments, based on a case study of the Universitat Oberta de Catalunya (Open University of Catalonia, UOC), an online university. A focus group was organized to gather students' views on the three mobile developments for the UOC's Virtual Campus: a native app, an adapted version for mobile browsers, and an e-mail client app.

1 INTRODUCTION

Smartphones and tablets are increasingly used by the general population and Spain, in particular, is one of the countries of the European Union with the highest levels of smartphone sales (Europapress, 2013). The expansion of the apps market appears unstoppable (Ticbeat, 2013), and uses are being found for mobile devices and apps in an increasing number of areas, including leisure, city management, public administration, education, etc.

The spread of mobile devices and apps has given rise to various debates, which centre around the technology itself, how this technology should be used (Maceiras et al., 2011; Piguillem et al., 2012; Rathi et al., 2012), how to guarantee a satisfactory user experience (Ballard, 2007, Nakhimovsky et al, 2009), and the relative merits of native, web and hybrid apps (Budiu, 2103; Charland, 2011).

In education – particularly the higher education sector – debate over mobile apps must also incorporate consideration of the use of mobile devices and apps for teaching and learning, or *m-learning*, (see, for example, Barnes, 2013).

As such, if a university wants to adapt its virtual learning environment for mobile devices it will need to take decisions regarding educational content, technological structures, and the desired form of human-computer interaction (HCI).

While there is already a body of literature on m-learning (Barnes, 2013; Gikas, 2013), the relationship between m-learning and UX (Dirin, 2013), and the types of technology and platforms that can be used to in adapting a virtual learning environment for mobile devices (Xhafa et al., 2010), there is an obvious lack of studies addressing the views of students, not with regard to the learning process itself but in respect of their capacity as users of both mobile devices and mobile learning environments. In other words, the literature contains little consideration of the extent to which virtual campuses are adapted to the real needs of their *users*.

Questions that must be asked include the following: If a university offers a wide range of services, which are the most relevant to students when they connect from a mobile device? Would students prefer to use a virtual campus specifically adapted for mobile browsers, a native app, or the choice of both? If the university intends to develop an app, would students prefer a single app that combines only the most relevant services or individual apps for each of the services offered?

In this paper we aim to shed light on the options open to a university when developing a mobile learning environment, based on the perspective of the student-user. Specifically, we present a series of recommendations based on a case study (Eisenhardt,

1989) of the Universitat Oberta de Catalunya (Open University of Catalonia, UOC), an online university. A focus group was held with UOC students to gather their views on the mobile developments currently offered at the UOC and the direction work on these developments should take in the future.

The mobile developments discussed in the focus group were: an adaptation of the UOC Virtual Campus for mobile browsers; a native app of the Virtual Campus; and a native e-mail client app.

In the following sections we describe the three mobile developments and explain the objectives and composition of the focus group and the results obtained from the discussion. Finally, we present a series of conclusions and the recommendations for other universities.

2 MOBILE DEVELOPMENTS AT THE UOC

As stated above, the focus group was used to discuss the adapted version of the Virtual Campus for mobile browsers, the Virtual Campus native app, and the e-mail client app.

The UOC Virtual Campus works as a portal where students have access to all the different services necessary to carry out their studies, such as e-mail, the agenda, classrooms, news, library, secretariat, and so on.

Optimized access to this learning environment from mobile devices was both a necessary step and an inevitable development. The growing use of smartphones across society as a whole, and the general profile of UOC students, who want to make the most of any chance to carry out activities related to their studies, have made it increasingly important to provide an effective means of connecting to the Virtual Campus from mobile devices (Gil-Rodríguez, 2010).

Following a user-centered design methodology (ISO; 2010), in an initial phase a series of focus groups (Rebaque-Rivas, 2010), context studies (Gil-Rodríguez, 2010) and usability tests (internal document) were organized with UOC students to find out about their requirements and to assess the different design proposals deriving from their comments. The results were used to define the functions and services that students consider essential in a mobile learning environment.

Having completed the initial research in 2011 the UOC launched the adapted version of its Virtual Campus for mobile browsers (Office of Learning Technologies - Open University of Catalonia, 2011). The new version has three main tabs: *My UOC*, which gives students access to the principal range of academic services (e-mail, virtual classrooms, calendar, etc.), adapted for mobile devices; *Menu*, which lists the other services available in the standard Virtual Campus, which are not adapted for mobile devices but are considered useful enough for links to be provided; and *Alerts*, which provides direct access to the main information and notification spaces of the Campus (e-mail, virtual classrooms, work groups, teacher board, etc.).

The simultaneous availability of conventional and mobile services was one of the main points considered during the focus groups.

Development of the native app began in 2011 through a joint initiative with Orange Spain to design a Virtual Campus for exclusive use on iPads (Gil-Rodríguez, 2011). The app was refined and enhanced before being made available in late 2012 as a download from Google Play and the Apple Store for the UOC community.

Unlike the adapted Virtual Campus for mobile browsers, the native app only contains those services that students identified as essential: e-mail, virtual classrooms, alerts, news, agenda, and learning resources.

The e-mail client, launched for Android at the beginning of 2012, was the first UOC app to be released. It is essentially a “light” version of the standard web client, providing a smaller number of key functions (inbox, folders, and compose messages).

3 FOCUS GROUP

In this section, we describe the objectives, methodology and composition of the focus group and the principal results obtained.

3.1 Objectives, Methodology and Composition

The Virtual Campus native app was launched in September 2012, alongside the mobile browser version and the native e-mail client. The simultaneous availability of multiple mobile developments was considered to be a potential source of confusion among students, who would have to consider the relative usefulness of three different tools, the type of use they would be likely to make of each one, and their preference for a native app or an adapted learning environment for mobile browsers.

A focus group was organized with UOC students to find out the extent to which they are aware of the mobile tools developed by the UOC, the use they make of each one, and their satisfaction with the functions provided. The students were also asked to give their opinion of the combination of sections adapted to mobile browsers and sections for traditional browsers within the mobile version of the Virtual Campus.

Specifically, we hoped to obtain information on students' patterns of use and connection habits beyond strictly quantitative data (4% of total connections to the UOC's Virtual Campus are made from smartphones, of which 50% are iOS handsets, 38% are Android, 8% are BlackBerry and 4% are other platforms (internal document). This data differs from the Spanish market shares of the major smartphone operating systems: Android, 92%; iOS, 4,2%;, Windows 8, 1,9%; Symbian 0,9%; BlackBerry 01% (Europapress, 2013). We also aimed to determine the degree to which students are aware of the different mobile developments offered by the UOC, the use they make of each one, and their views on the simultaneous availability of different tools, as the basis for consideration of possible improvements and potential developments in the future.

For the focus groups, smartphones and tablets were used to access the different mobile developments, with demonstrations projected in real-time to facilitate in-depth discussion and evaluation of the students' views. Students were also given the chance to access and browse the tools themselves (although they used their owned devices for these tasks).

The sample taking part in the focus groups contained representative proportions of male and female students, 50% of whom had been UOC students for more than one year and 50% less than one year. The students were aged between 25 and 45 and were enrolled in different degree courses (Business Administration and Management, Communication, Public Relations, Systems Engineering, and Criminology). Students were selected on the basis of being regular users of a smartphone and tablet (some had actually bought their smartphone or tablet with their UOC studies in mind, together with other factors). In addition, almost all of the students divided their time between study and work.

3.2 Principal Results

In this section, we present the principal results for the main aspects discussed in the focus groups: 1) patterns of use, connection habits and choice of devices for connecting to the Virtual Campus; 2) evaluation of the adaptation of the Virtual Campus for mobile browsers; 3) evaluation of the Virtual Campus native app; 4) evaluation of the e-mail client app; and 5) future of the developments.

3.2.1 Virtual Campus: Patterns of Use, Connection Habits and Choice of Devices

For most UOC students, one of the main factors in choosing to study at an online university is the need to combine their studies with other activities, in particularly their jobs.

As such, the patterns of use identified in the focus groups were not completely uniform, varying according to the students' non-academic commitments. Nevertheless, a few general observations were made:

- Students connect almost every day to check for messages and notices, including updates to forums, email or messages from lecturers, work groups, debates, etc.
- Students generally browse the Virtual Campus or connect to study at night or after lunch time.
- The students' view on the importance of the flexibility that the UOC provides depends to an extent on the number of subjects in which they are enrolled (which, in turn, depends on the time available for study and each student's budget).
- The periods during which students connect are determined in part by the academic calendar, with more frequent connections registered when assessment tests are due for submission or when marks are posted.

Two distinct uses of the Virtual Campus were detected: 1) to obtain information, for example by checking for alerts and notices, viewing documents, obtaining marks and consulting documentation on continuous assessment tests; and 2) to work, for example by downloading, completing and submitting continuous assessment tests, and sharing information with other students, lecturers or tutors.

With regard to the choice of devices for connecting to the Virtual Campus, the primary options are laptops or desktop computers, complemented by less frequent use of smartphones and/or tablets.

Laptops and desktop computers are used for both of the principal activities referred to above (obtaining information and working) as the students find them easier to work with. This is due in part to the screen size, but also reflects the availability of material and the ease of carrying out continuous assessment tests on the larger devices. Students also suggested that they feel more secure about carrying out their work on laptops and desktops.

In the case of smartphones, during the initial research we found that most students were not aware of the developments we aimed to test in the focus groups and that comments on connection habits actually related to an unofficial mobile version of the Virtual Campus developed by a UOC student as a final degree project, or to the standard Virtual Campus accessed from a mobile browser. As such, the data on connection habits via mobile devices could not be considered conclusive.

Students use smartphones devices mainly to check for daily updates and notices in the communication areas of the Virtual Campus. One student explained: *"Whenever I have a break from work I check my mobile to see if anything new has come up"*. The students value the mobility and immediacy of a smartphone for obtaining information, although they acknowledge that it is not very practical for consulting documentation; indeed, a common complaint was the incompatibility of smartphones with Office tools.

Finally, the students use tablets primarily for viewing documents. They define tablets as comfortable and practical devices that enable them to read in situations where it is easier and more user-friendly to use a handheld device than a computer. As one student described: *"... While you're away, at the weekend, on the train, on the sofa ..."*.

3.2.2 Virtual Campus for Mobile Browsers

Following a demonstration of the mobile version of the Virtual Campus and having been given to chance to access the adapted version from their own devices, students were asked to give their opinions of the development (see Figure 1).

We found that there was generally little awareness of the mobile version of the Virtual Campus. Most students were more accustomed to checking the standard Virtual Campus from their smartphone or tablet, either because the standard version opened automatically or because they had not found the link to the mobile version.

Having watched the demonstration and used some of the functions of the mobile version from their own devices, students commented that they particularly valued the practicality of the adapted Virtual Campus, in the sense that it contains all of the most relevant information for connections from a mobile device.

The most negative comments reflected the students' dissatisfaction with the fact that some sections, such as *Secretary's Office* and *Tutor*, had still not been adapted for mobile browsers, while there were links to other sections that students were unlike to use from a mobile device, including *Library* and *News*.

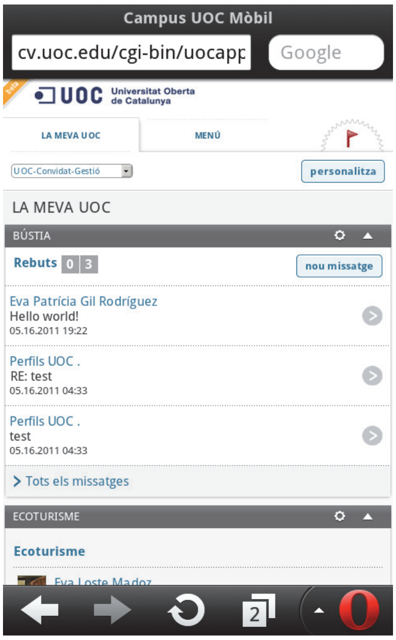

Figure 1: Virtual Campus adapted for mobile browsers.

Students were not critical of the combination of sections adapted for mobile browsers with other sections designed for traditional browsers, as they understood that the mobile version was still in the development stage. However, students did stress that it would only be necessary to adapt those sections they were most likely to connect to from a mobile device, such as the academic record, alerts and notifications, the teacher board, forums, subject work areas and agenda.

3.2.3 Virtual Campus Native App

Students were shown an on-screen presentation of the native app and were given the chance to use it on their own devices (see Figure 2).

We again found that only a small number of students were familiar with the app. In fact, the students who had used it were generally those who had enrolled at the UOC most recently. In some cases, as observed above, students confused the native app with the unofficial tool that is also available.

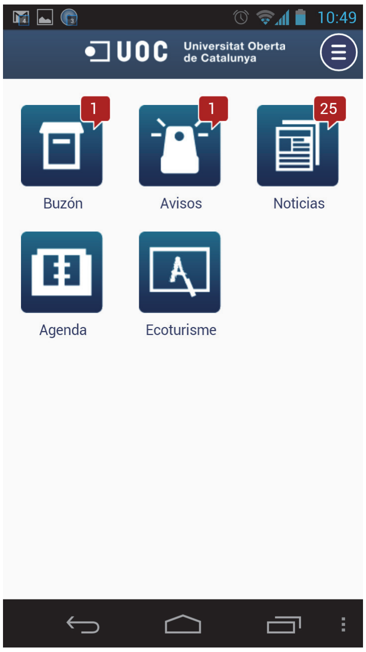

Figure 2: Virtual Campus native app.

The most positive comments reflected the students' satisfaction with the fact that the app meets their preferences and corrects the problems encountered with the mobile version of the Virtual Campus; in other words, it only contains the information students consider relevant for connections from a mobile device. As one student remarked: *"It's like a pared-down version of the mobile version, it has everything you need"*. They also remarked that the app is modern, innovative and functional, which transmits a good image of the University as a whole.

The most negative comments received from students – in line with their appraisal of the adapted version of the Virtual Campus for mobile browsers – referred to the absence of the *Tutor* and *Secretary's Office* sections (particularly as this prevents them from consulting their academic records – they are less concerned about being able to manage tasks) and the lack of a general option to personalize the app.

Students also suggested that the sub-folder structure should be improved for communication in forums, virtual classrooms and via UOC e-mail, as the current structure creates a feeling of uncertainty and generates concern that if students are unable to connect to the full Virtual Campus they may be missing out on information. It should be noted, however, that at the time the focus group was arranged, the native app was affected by a technical issue and could only display the principal folders in the forums, classrooms and e-mail.

3.2.4 e-Mail Client App

Finally, the e-mail client app was presented, following the method adopted for the previous two developments (see Figure 3).

Figure 3: UOC e-mail client app.

Students most highly valued that the app is a quick solution for accessing their UOC e-mail. They were less positive about the fact that the client app is basically a substitute for the native Virtual Campus app, making it both too specific and not sufficiently comprehensive. As such, it does not meet the students' information requirements, as they will also need to view other types of messages and alerts. As one student explained: *"When I want to check something at the UOC it's not just my in-box, it's to see whether there are messages on the notice board, the forum…"*.

In other words, the students considered that all of this information should be gathered together in a single app and that the e-mail client serves no useful purpose, given that they can already check their e-mail via the Virtual Campus native app. They explained that having a number of different tools creates a degree of uncertainty. As one student pointed out: *"If you have to check various apps, you get the feeling that you might be missing out on information"*.

3.2.5 Future of the Developments

Once the three developments had been presented, students were asked to give their views on how they should be developed in the future and what use they are likely to make of each one.

The students indicated that they would connect most frequently to the native app, as they see it as the most direct form of accessing the Virtual Campus and consider that it includes enough of the necessary services (lacking only the *Secretary's Office* and *Tutor* sections, as they mentioned), unlike the adapted version for mobile browsers.

The students also suggested functions that they would like to see integrated into the native app. These include a file storage and sharing system, such as an internal server or a tool along the same lines as Dropbox, compatible with all mobile ecosystems, in order to access their records (documents, continuous assessment tests, messages), and an instant messaging tool similar to WhatsApp, to facilitate interaction in specific tasks such as group projects.

With regard to the potential use of different types of hardware (conventional computers and mobile devices), the students consider that they will continue to use a combination of the two, and that mobile devices are unlikely to replace computers altogether.

As tablets becomes more widely adopted, and once assessment tasks can be carried out from these devices, students believe that use will probably increase, and that tablets could even become the principal tool for certain tasks. The consensus is that tablets could become an active part of their studies and could even be the main device for connecting to the Virtual Campus, as it was also pointed out in the NMC Horizon Report 2013 (Johnson et al 2013) in which tablets were identified as one of the key trends in education and are regarded as having immense impact on learning and teaching in the next up to five years.

With regard to smartphones, students indicate that they will continue to be an important means of connecting to the Virtual Campus, as a complement to computers and tablets.

As such, students believe that the ideal solution in the future will be an offer of services that are fully functional via mobile devices, although they acknowledge that total adoption would be difficult to achieve. Indeed, as one student commented: *"It's a physical thing – It seems strange to think that I could actually write or work on a tablet, let alone a smartphone".*

Finally, in relation to the availability of the three developments and the general lack of awareness among students, and taking into account the unofficial app that many students were aware of, it can be concluded that students would like improvements to be made in the way launches of new developments and tools are communicated. As one student pointed out for the specific case of the mobile app: *"We could have been sent an e-mail: 'Download the app'."*

4 CONCLUSIONS

The focus group with students yielded a series of conclusions from which recommendations can be drawn to guide other universities in planning the adaptation of a virtual learning environment for mobile devices. In this section we describe in detail the conclusions of the focus group. The resulting recommendations are presented in the following section.

As a general conclusion, the students were satisfied with the mobile browser adaptation and the native app and considered that they provide a comprehensive answer to their current connection needs, as well as portraying the UOC as a modern, innovative university. However, students also suggested that they would only use the native app, as it integrates and links to the most relevant services, and ruled out using an e-mail client app or the mobile version of the Virtual Campus.

For the native app to be fully satisfactory, three principal improvements must be made: 1) direct access from the app to a full range of services demanded by students, who indicated that they would like to see a section for consulting marks and a link to the *Tutor* section; 2) an integrated instant messaging system to allow fluid and fast communication with fellow students; 3) a system for storing, sending and sharing files.

On the other hand, the students' regular use of smartphones and tablets to connect to the UOC Virtual Campus, their opinion about considering tablets as the potential main device for these connections in the near future, and as well as their positive appraisal of the native app underline the fact that the mobile learning environment is already an integral part of students' day-to-day activities. It is therefore necessary to provide them with an optimized means of accessing the Virtual Campus from smartphones. The rise in sales of smartphones, the importance of anywhere connectivity, the general adoption of mobile apps, and the opportunities brought by mobile devices in educational settings (UNESCO, 2012, Johnson et al, 2012, Johnson et al., 2013) underline the delay with which universities have moved to adapt their virtual learning environments for mobile devices.

Finally, it should be noted that most students were either unaware of the mobile developments described in this paper, even though they have been available for some time, or were familiar with unofficial apps before they learned about the official versions. It is clear, then, that efforts to communicate the availability of these developments failed, hence greater efforts should be made to provide students with more direct information about new tools and enhancements, rather than expecting students to “discover” them unaided.

5 RECOMMENDATIONS

In the following table (see Table 1) we present a series of recommendations drawn from the UOC case study which may be of assistance to other universities interested in developing mobile learning technologies.

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Table 1: Recommendations to guide universities in the development of mobile learning environments.

A single native app	Developments should be unified in a single app that brings together the most relevant services for students. This is preferable to offering multiple apps, each dedicated to a different service, which may be perceived as overly specific or lacking functions, or an adapted version for mobile browsers, which would provide access to a series of services that students are unlikely to use from mobile devices.
What the student-user requests	Students periodically use a smartphone or tablet as an alternative to a computer. But the services they are expecting to find and use in the mobile learning environment may be different from the services found in the computer learning environment. Therefore it is crucial to know what these students’ requirements are in order to design and develop a mobile learning environment according to their needs, and as a consequence to assure a satisfactory user experience. As referred to in the previous recommendation, offering other services that cannot easily be used via a mobile device could distract and hinder the students’ goals when using the mobile learning environment and, as well as generating unnecessary development costs. Employing a user-centered design perspective is an optimal way to achieve these objectives.
Devices and contexts	Regular use of smartphones and tablets by students makes it necessary to design and develop mobile learning environments taking into account both devices and their respective contexts of use.
Document management function	Although it is difficult to create or edit documents from a smartphone, an option within the mobile learning environment to save, manage and share documents gives students greater *in situ* control over their work and records, without having to wait until they can use a computer.
Instant messaging function	The emergence and mass adoption of instant messaging apps typified by WhatsApp have created a need among students for rapid and efficient communication within the mobile learning environment, particularly for group work.
A good impression	The availability of a Virtual Campus app gives a good impression and portrays the university as a modern, innovative institution.
Effective communication of new developments	New developments, tools and enhancements must be communicated effectively. Options include providing information on how to access a new development, for example in the form of an e-mail with a link to the tool, or clearly marking links to the enhanced version of an existing tool from the previous version. The strategy should focus especially on students who have been enrolled at the university for some time, who are more likely to have developed a routine and may be less receptive to new tools or less active in the search for new options.

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SHORT PAPERS

Experimentation Comparison in Virtual and Practical Operation
Take Hydraulics Learning for Example

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Keywords: Virtual and Practical Operation, Experimentation, Hydraulics Learning.

Abstract: The objective of this research is to examine if practical or virtual operating experimentation can discriminate hydraulics learning. There are several experimental situations, specifically virtual operating experimentation (VoE), practical operating experimentation (PoE), two successive conjunctions of VoE and PoE, and a control situation (i.e., conventional instructing with lack of VoE or PoE). College learners' comprehension of hydraulics notions in the field of force and distance is examined in a pre-post test plan that included 57 members appointed to the control group and 195 members appointed to the four experimental groups. Conceptual exams are dominated to evaluate learners' comprehension throughout instructing. Results revealed that the several experimental situations are similarly efficient in enhancing participants' comprehension of notions in the field of force and distance and better than the control situation; therefore, operation, virtual or practical operation, and not substantiality, at lowest in a condition as the one of the proposed research, is essential in hydraulics learning.

1 INTRODUCTION

Many studies have focused on reform in engineering education in recent years, they were stressed the significance of experimentation in engineering education (Hamalainen, 2008; Liang, 2009; Pennsylvania Department of Education, 2010; Zacharis, 2011). One cause making this a crucial request is quick expansion of virtual operating experimentation (VoE) and its connotations for many fields in engineering. The VoE includes the utilization of virtual equipment and component that appear in virtual circumstance (e.g. computer-based simulation). Many empirical researches indicated the possibility of VoE to promote learners' abilities and comprehension of engineering knowledge during the past decade (Hamalainen, 2008; Zacharis, 2011; Liang, 2010a; Gao, Cai, Zhao, Liu & Xu, 2010). Although these discoveries, many educators have started to sternly ask if experimentation at workshop, as we perceive it by means of the utilization of operational experimentation in automotive troubleshooting (OE_in_AT), namely, application of tangible component, tool and equipment in real world, should be reconstructed to involve VoE (Liang, 2010b; Zacharis, 2011).

Besides the PoE and VoE advocates, there are researchers who advocate associating the utilization of PoE and VoE. Through this mode of experimentation, the advantages of two operations can be acquired (Goldstone & Son, 2005; Winn et al., 2006; Zacharia, 2008). Even though in this condition, substantiality, if it verifies to be a prerequisite for learning, is still a subject because when VoE is applied, the drawbacks (no substantiality) which it delivers is still present, hence, negatively influencing learners' learning. It could be the situation that for several experiments inside the identical circumstance (e.g. identical field and techniques included but different experiment) the substantiality is not always need to show. Yet there is no study in this field so far approving or inquiry such a presumption.

2 LITERATURE REVIEW

The substantiality is the most primary distinction between VoE and PoE, which for VoE supporters, seems not to be a particular necessity for learning, unless the goal technique is sensory-motor. From a theoretic aspect, the supporters in virtual operation demand that the substantiality is a necessity for learning is not educated in any of the present main learning theorems, that is, the learning theorems of cognitive and constructivist. The former stresses the requirment for learners to energetically deal with messages and exercise the goal technique (Triona & Klahr, 2003). The latter focuses on the significance of learners playing an energetic character in learning, whereas it does not specially need to practical operation. From a perspective in experimental study, there are a few researches that directly examined the result of substantiality on field learning (Flick, 1993; Triona & Klahr, 2003; Klahr et al., 2007). The findings of these studies reveal which substantiality seems not to be a necessity towards particular learning techniques (Triona & Klahr, 2003) or activities (Klahr et al., 2007). Nevertheless, one can not deduce from these researches if substantiality is a prior necessity for comprehending engineering conceptions.

On the other hand, VoE involves operation of component and equipment that is essential for learning, but the essence of operation is rather virtual than practical. Nevertheless, handling virtual operation does not make over the substance of operation by itself (Triona & Klahr, 2003); virtual operation is still a procedure, as with regard to practical operation, which takes purposeful interactions with component and equipment in a skillful way. Learners can still plan, manipulate, or handle the “identical” component and equipment, as in practical operation. The only distinction is that with regard to PoE these purposeful interactions are executed by learner’s hand (e.g., through holding and lifting), but with regard to VoE they are executed by virtual ways (through clicking and dragging by a keyboard or mouse of computer). Therefore, because of the lack of substantiality (real and active contacting), virtual operation also disagrees from practical operation in the kind of motion techniques that are utilized in the operation period. Nevertheless, VoE supporters stress that suchlike a perceived import is unlikely to be especially essential towards learning (Triona & Klahr, 2003). Going back the instance of elevating a lift piston with a sample of hydraulic oil, when applying a VoE, as with regard to PoE, the student even has the possibility to trace the identical operational procedures in conveying the lift piston at the targeted distance (takes the lift piston on the lift side of automobile hydraulic lift, setup a digital laser tape measure on the base of lift piston in automobile hydraulic lift, then input the force on another side of automobile hydraulic lift for a definite time), and to obtain the identical response that correlates to the goal of the learning activity, which this situation is to achieve a definite distance (reading from the digital laser tape measure). As a matter of course, VoE and PoE do not offer the student the identical whole response. In truth, although you confine the usability of VoE in offering extra response to the one offered by the digital laser tape measure (e.g., response that is notional in essence, for instance, hydraulic oil particle progress), you must not exclude the practical perspective from PoE that offers touch perceived import when operating the components of the experiment (e.g., a sensation of hydraulic oil pressure is at the starting of the experiment). However, for the targets of the experimental activity of our instance, such a perceived import of tactile sense seems not to be essential for how to press hydraulic oil and gauge its distance.

3 HYPOTHESES OF RESEARCH

Presented the above mentioned different disputes of VoE and PoE supporters and the absence of an accordant theorem on substantiality and its relationships to hydraulics learning, comparing hypotheses about the result of substantiality are systematized. Regarding the first research issue, it is supposed that the PoE only, but not the VoE only, situation will promote learners’ comprehension of *F&D* (Force and Distance) concepts as contrasted to the control situation (Hypothesis 1a). In comparison, in the light of VoE supporters, both VoE and PoE will promote learners’ comprehension of *F&D* concepts as contrasted to the control situation (Hypothesis 1b). With regard to the second research issue, the PoE supporters dispute that substantiality is essential in hydraulics learning and, hence the students in the PoE only situation will have preferable comprehension of *F&D* concepts than those in the VoE only situation (Hypothesis 2a). Besides, if substantiality is not essential in hydraulics learning, then there will be different between the results of VoE and PoE on the comprehension of *F&D* concepts (Hypothesis 2b).

With regard to the third research issue, from the PoE supporters’ aspect, the PoE only situation will promote learners’ understanding of *F&D* concepts over the situation of fractional disclosure to substantiality with VoE subsequent PoE; furthermore, both of them will have a more powerful result than the situation of fractional disclosure to substantiality with PoE subsequent VoE and the control situation; eventually, the situation of fractional disclosure to substantiality with PoE subsequent VoE and the control situation will not vary between them (Hypothesis 3a). In comparison, if substantiality is not essential for learning hydraulics, in that case whole four experimental situations will be identically efficient and more profitable than the control situation for enhancing learners' comprehension of *F&D* concepts (Hypothesis 3b). Concerning the fourth research issue, it is assumed that the situation of fractional disclosure to substantiality with VoE subsequent PoE will enhance learners' comprehension of *F&D* concepts more the situation of PoE subsequent VoE (Hypothesis 4a). The opposite assumption is that the two sequences will not vary in their results on learners' comprehension of *F&D* concepts (Hypothesis 4b).

4 RESEARCH METHOD

4.1 Participants

There are 252 participants, undergraduate members (70 female, 182 male, ***M*** = 20.4 years, ***SD*** = 0.72), enrolled in a course of introductory hydraulics at a college in this research, purposed to service car company engineers. This research is arranged in three consecutive semesters. The 57 members are assigned to the control group (CG, S_{cg}) in the first semester, even though, for the others (195 students), data are gathered in subsequently two successive semesters. Especially, 124 members are divided into two groups randomly, that is, Participants are applied VoE only in the experimental group I (EG_I, S_{eg}_I; 65 members) and participants are applied PoE only in the experimental group II (EG_II, S_{eg}_II; 59 members) in the first semester period, and 71 members are divided into two groups randomly, that is, participants are applied both VoE and PoE with PoE subsequent the application of VoE in the experimental group III (EG_III, S_{eg}_III; 36 members) and participants are applied both VoE and PoE with VoE subsequent the application of PoE in the experimental group IV (EG_IV, S_{eg}_IV; 35 members) in the second semester period (as shown in Figure 1). The units involved to the control situation quote the identical topics and conceptions as in the experimental situations.

All participants followed the identical course, introductory hydraulics, and all members had the identical age and educational background. All participants of whole five groups had no taken college layer hydraulics before the research or are joining any other hydraulics course during the research. The exams of this research are finished at a pre-arranged time outside this program.

In one-way ANOVA (a kind of quantitative analysis), it reveals that the achievement scores are not significantly difference among the members in the control group and all experimental groups, as shown in Table 1. Regarding the qualitative analysis, it indicates that the type and character (received in engineering) of learners' conception do not disaccord, across whole of the classifications of notions explored: with regard to distance, $\chi^2(4, n = 252) = 0.42$; as regards changes in distance, $\chi^2(4, n = 252) = 1.76$; concerning force, $\chi^2(4, n = 252) = 0.35$; regarding force transfer, $\chi^2(4, n = 252) = 1.58$; towards viscosity, $\chi^2(4, n = 252) = 1.63$; and for density, $\chi^2(4, n = 252) = 4.92$. Meanwhile, the *p*-value of all above items is greater than 0.05.

Table 1: The results of means and SD in each of the exams.

Group	Exam_1	Exam_2	Exam_3	Exam_4	F&D exam
S_{eg}_I pre-test	20.0 (8.0)	30.2 (7.7)	26.1 (9.0)	23.0 (11.8)	31.1 (9.5)
post-test	72.8 (13.7)	67.0 (6.9)	58.2 (14.6)	80.7 (16.4)	66.9 (12.2)
S_{eg}_II pre-test	23.5 (7.9)	32.5 (6.6)	24.7 (9.4)	29.9 (10.0)	32.6 (10.7)
post-test	73.3 (9.6)	68.3 (8.2)	57.0 (15.9)	81.4 (17.3)	66.4 (13.0)
S_{eg}_III pre-test	22.8 (7.8)	33.4 (6.5)	23.8 (8.8)	29.0 (11.3)	33.0 (14.1)
post-test	77.8 (12.7)	69.1 (10.4)	59.0 (13.2)	78.0 (15.4)	64.4 (15.4)
S_{eg}_IV pre-test	23.4 (5.3)	33.0 (5.3)	25.5 (10.2)	27.6 (9.3)	32.8 (11.1)
post-test	73.1 (11.4)	68.7 (9.0)	59.7 (13.6)	81.0 (12.8)	63.3 (13.6)
S_{cg} pre-test	21.5 (7.5)	31.6 (7.0)	25.4 (8.0)	28.5 (12.4)	32.4 (14.5)
post-test	50.2 (9.5)	52.6 (8.6)	37.9 (10.1)	56.3 (11.8)	46.7 (11.6)

4.2 Experimental Design

Figure 1 illustrated a pre-post test experimental design in this research. A VoE state of high accuracy is employed; it keeps the interactions and properties of the subject field of the research as PoE does. In addition, the identical level of plenty and clarity are achieved in both the VoE and PoE states, and to locate both VoE and PoE inside the identical context of teaching; that is, the identical teaching method, identical instructors, instructing contents (Hydraulics and Pneumatics: A Technician's and Engineer's Guide, Parr, 1999, pp.7-23) and procedures (as assigned by the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course; e.g., learners engage in small teams during the course) are utilized. The adoption of this course is on the basis of the truth that it promotes learners' comprehension of hydraulic concepts over more conventional, inactive ways of teaching (Chanson, 2004; Chua, 2011).

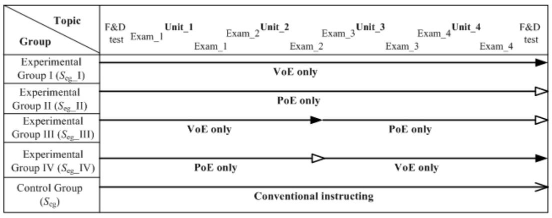

Figure 1: The experimental design of the research.

In the execution of experimental research, it is included the contrast of the result of VoE (i.e., no disclosure to substantiality), PoE (i.e., disclosure to substantiality during the research), two consequent conjunctions of VoE and PoE (i.e., fractional disclosure to substantiality) and conventional teaching (i.e., exclusion of practical and virtual operation of components and equipment) on undergraduate students' comprehension of hydraulics conceptions in the field of *F&D*. In both the experimental and control situations the identical course matter (identical four units from the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course, pp. pp.7-23) was applied. With regard to the control group, the teaching contents are expressed to the participants by discourses that included expositions of the research's experiments. The expositions are constructed by the utilization of films or projected on a screen by the teacher. The experiments involved in all expositions are conducted by PoE. The concept behind the expositions is to meet what the participant's perception in both the experimental and control situations.

4.3 Contents of Instruction

The first four units of the module of Force and Distance (*F&D*) of the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course is employed for the goals of this research. The first unit (Unit_1) generates a manipulative definition for distance, the second unit (Unit_2) investigates distance changes when examples of big-size or small-size piston (i.e., contact area) are used, the third unit (Unit_3) depicts notions regarding force and force deliver in the condition of two pistons of various areas which mutual influence continuously. Meanwhile, this unit discriminates the character of distance and force in dynamic interactions. The last unit (Unit_4) introduces the fluid properties of matter, particularly, viscosity and density. In the four units, the participants are stimulated: (a) making the required psychical commission by conducting them through the procedure of generating a conceptual framework for how distance changes beginning from direct the experience of doing in person that includes applying different size of contact surface, as well as different viscosity of hydraulic oil, and (b) developing the notions essential to depict substance regarding its fluid attributes.

4.4 Activities and Evaluations

The identical conceptual exam (F&D exam) is administered to estimate participants' comprehension of *F&D* concepts concerning distance, changes in distance, force, force transfer, density, and viscosity both before and after this research. In addition, exams specific to each unit of the research are executed before and after introducing each unit (from Exam_1 to 4; see Figure 1), with each exam being same before and after each unit. Each of the exams includes several portions (some that is composed of two sub-portions and every sub-portion has at lowest one question) that inquire open-ended notional problems all of which need to make a description of inference. The *F&D* exam involves six open-ended portions in order to measure all units of the research's course. This exam aims both the particular notions presented in each unit and the correlations of these notions. Each portion of each exam is scored respectively; for exact responses, nevertheless, a total mark is obtained from each test and utilized in the analysis. All exams are calculated and recorded no matter the situation that the participant is arranged. The marking of each portion is executed by means of the application of a marking annotation table that included pre-assign rules (exact answer and exact description), which are applied to mark both whether a member's reply to a question and its followed description are exact. An exact solution to a question is marked with one point, for all exams, and its consistent description in the light of how many of its pre-assign rules (anticipated knowledge required to describe a solution) are matched. Each description rule is marked with different point, across every exam. The maximum score of each question of a portion of an exam differs in accordance with the count of rules utilized for marking its description. Hence, the maximum score of a portion of an exam differs both across the portions of an exam and across the portions of the other exams, unless two portions share the identical amount of description rules. A single total score on an exam is obtained by summing up all the specified score, both those of a solution and a description, of all questions of an exam, and by regulating it to a one hundred-point scale. The range of total mark is limited from 0 to 100 on each exam. Two independent raters marked about twenty percent of the data. The reliability measures (Cohen's kappa coefficient) for marking of the *F&D* exam (pre-post test) and Exam_1, Exam_2, Exam_3, and Exam_4 (pre-post test), are 0.91, 0.92, 0.89, 0.90, and 0.89, separately. The reliability (agreement ratio) of the qualitative data (participants' conceptions) is 0.92. Disagreements are investigated after the analysis of reliability, and are categorized while reciprocal agreement is approached.

4.5 Procedure

In spite of the truth that the data accumulation happened at distinct phases, the processes traced are same at whole times. Firstly, all groups are created after random appointment of the members to a specific situation. Participants in all experimental groups trained in the identical workshop circumstance that administers both traditional equipment and computers organized in the surroundings, whereas members in the control group joined the course in one of the college's curriculum. Secondly, within each situation participants are randomly appointed to sub-teams as proposed through the course of this research (in a number of groups there are 2-students sub-teams due to the entire members in the group is not adequate to become triads). With regard to the control group, members trained in sub-teams of three merely during the solution of course book problems. Thirdly, whole participants are dominated the *F&D* pre-test before getting dealt with the processing of the situation they belong do. Meanwhile, concise descriptions that endeavor to accustom participants with the contents they are on the point of utilizing. Members in the control group are presented to the course book that is arranged for them and the processes that they will trace all over the course. Members in the all experimental group are presented to the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course and both VoE and PoE by an exposition despite their situation. The presentation to the procedures and methods of the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course is very essential since they distinct from those included in the more conventional, inactive modes of instructing that participants have undergone in hydraulics courses in their school years period. In contrast, participants are taken accountable in hydraulics learning and are anticipated to together establish knowledge and generate their comprehension of hydraulics notions by the guidance of a cautiously planned, framed succession of query-oriented experiments.

Finally, conceptual exams are also performed both before and after each unit except the teaching of each unit (see Table 2). There are 18 weeks included in the research period. Participants have three-hour meeting per week. The all groups have the same time schedule on activities (as shown in Table 2). In execution stage, we dominated for any abnormalities between the time schedule on activities athwart whole situations (it is found anywhere else to influence member's learning; note an example Zacharis, 2011), especially amongst the experimental groups thanks to a discrepancy in the probabilities afforded by VoE and PoE for pressing hydraulic oil. For instance, because it takes participants utilizing practical operation more time to carry a lift piston to a definite height through the use of hydraulic oil than the members utilizing VoE, the groups that employed PoE are offered with pre-install substance (such as pre-pressed samples of hydraulic oil) to save time on routine activities.

Table 2: Time-on-activity data in each group.

Activity	Time				
	S_{eg}_I	S_{eg}_II	S_{eg}_III	S_{eg}_IV	S_{cg}
	Hours/ Week	Hours/ Week	Hours/ Week	Hours / Week	Hours / Week
F&D exam	1.5 / 1	1.5 / 1	1.5 / 1	1.5 / 1	1.5 / 1
Introduction	1.5 / 1	1.5 / 1	1.5 / 1	1.5 / 1	1.5 / 1
Exam_1	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2
Unit_1	12 / 2-6	12/ 2-6	12/ 2-6	12/ 2-6	12/ 2-6
Exam _1	1 / 6	1 / 6	1 / 6	1 / 6	1 / 6
Exam _2	1 / 6	1 / 6	1 / 6	1 / 6	1 / 6
Unit_2	10/ 7-10	10/ 7-10	10/ 7-10	10/ 7-10	10/ 7-10
Exam _2	1 / 10	1 / 10	1 / 10	1 / 10	1 / 10
Exam _3	1 / 10	1 / 10	1 / 10	1 / 10	1 / 10
Unit_3	10/ 11-14	10/ 11-14	10/ 11-14	10/ 11-14	10/ 11-14
Exam _3	1 / 14	1 / 14	1 / 14	1 / 14	1 / 14
Exam _4	1 / 14	1 / 14	1 / 14	1 / 14	1 / 14
Unit_4	8/ 15-17	8/ 15-17	8/ 15-17	8/ 15-17	8/ 15-17
Exam _4	1 / 17	1 / 17	1 / 17	1 / 17	1 / 17
Pressure exam	1.5/ 18	1.5/ 18	1.5/ 18	1.5 / 18	1.5 / 18
Total	52.5 h	52.5 h	52.5 h	52.5 h	52.5 h

5 RESULTS

5.1 Performance of Exams

The results of means and standard deviations of performance scores are shown in Table 1. Meanwhile, a main result of group for all exams is revealed in the ANCOVA analysis. With regard to Exam_1, $F(1, 246) = 28.5$, partial $\eta^2 = 0.13$, and of post-test 1 points on members' pre-test 1 points, $F(4, 246) = 30.6$, partial $\eta^2 = 0.34$, yet no interplay between group and post-test points. Regarding Exam_2, $F(1, 246) = 34.7$, partial $\eta^2 = 0.12$, and of post-test 2 points on members' pre-test 2 points, $F(4, 246) = 25.6$, partial $\eta^2 = 0.28$, yet no interplay between group and post-test points. Concerning Exam_3, $F(1, 246) = 115.5$, partial $\eta^2 = 0.32$, and of post-test 3 points on members' pre-test 3 points, $F(4, 246) = 49.6$, partial $\eta^2 = 0.45$, yet no interplay between group and post-test points. As for Exam_4, $F(1, 246) = 78.6$, partial $\eta^2 = 0.22$, and of post-test 4 points on members' pre-test 1 points, $F(4, 246) = 28.2$, partial $\eta^2 = 0.30$, yet no interplay between group and post-test points. Eventually, with regard to the *F&D* exam, $F(1, 246) = 121.2$, partial $\eta^2 = 0.28$, and of *F&D* post-test points on members' *F&D* pre-test points, $F(4, 246) = 54.5$, partial $\eta^2 = 0.34$, yet no interplay between group and *F&D* pre-test points. Furthermore, the p-value of all above exams in the ANCOVA analysis is less than 0.001.

According to the Bonferroni-adjusted p-values for pair-wise comparisons, it implies that members' scores in the four experimental situations cross all tests are significantly higher than those of participants at post-test in the CG. However, it does not show any emergent distinct between the members' scores at post-test of the EGs cross all tests in the analysis of pair-wise comparisons. These results imply that the utilization of VoE only, PoE only, and the two successive conjunctions (PoE subsequent VoE and VoE subsequent PoE) promoted participants' comprehension of the *F&D* concepts over conventional teaching does; furthermore, that whole the experimental situations are similarly efficient in enhancing participants' comprehension of these notions.

5.2 Comprehension in F&D Concepts

In the qualitative analysis, it shows that the mostly equivalent notions are shared across *F&D* concepts studies in all EGs (i.e., distance, changes in distance, force, force transfer, density, and viscosity), as either acceptable notions in hydraulics (ANH) or not acceptable notions in hydraulics (NANH), both before and after the *F&D* exam is performed. The members in CG seem to share the identical ANH and NANH notions with the members in EGs only the research at the pre-test of each unit. In the *F&D* conceptual exam, most of the members of the experimental groups transit from NANH to ANH across the *F&D* concepts searched, after the four units are completed. The members in experimental groups have higher popularity for each ANH and lower popularity for each NANH cross whole post-tests than the CG. The popularity of each ANH and NANH of the members in the CG is discovered to be about the equivalent at the *F&D* pre-post test, as well as at each exam before and after each of the four units. Meanwhile, the equivalent most popularity NANH is shared across all pre-post tests in all groups. Eventually, these results reveal that the utilization of VoE and PoE, only or in successive conjunction, has the equivalent consequence on college participants' comprehension of *F&D* notions**,** that is to say, on the transformation from NANH to ANH and on the type of notions participants have after the each unit is completed.

6 DISCUSSION

In the proposed research, the objective is to explore whether operation or substantiality (virtual or practical) is essential for learning hydraulics at the college level, and especially in comprehension of hydraulics notions. The results of this research reveal that the utilization of VoE and PoE, either only utilized or in successive conjunction, while inserted in a context alike to the one of this research, can similarly promote members' comprehension of *F&D* concepts and over conventional teaching. These results verify several Hypotheses (from Hypothesis 1b to 4b) that coincide with past researches (Hofstein & Lunetta, 2004; Krivickas & Krivickkas, 2007). Meanwhile, these results also confront the common supposition of the PoE supports that substantiality is a necessity for learning hydraulics. Not one of the prophecies (from Hypothesis 1a to 4a) grounded on this supposition is not confirmed. In comparison, the results indicate that what is essential in learning hydraulics is operation, practical or virtual, instead substantiality, at least inside a context alike to the one of the proposed research. This result, of course, does not offer decisive indication that substantiality, mainly, is not a necessity for each student's comprehension of hydraulics notions, or that the model of working memory depicted above (Millar, 1999) and its result is not cogent in cognitive load and capability.

Furthermore, the proposed research is to examine whether disclosure to fractional substantiality, namely, whether joining the operation mode (virtual to practical or contrariwise) in the same order of learning activities as in VoE only and in PoE only will have a distinctive result on participants' general comprehension compared to VoE only and PoE only; also, to investigate whether the result is distinct when practical operation succeeds virtual operation and contrariwise. The results show that the two successive conjunctions, in which the operation mode is shifted, do not vary between VoE only and PoE only, thus confirming Hypothesis 3b. The truth that the shift of experimentation can take place without influencing participants' comprehension offers sustain to Triona and Klahr's (2003) address that the perceived import deriving from the accordant operation or motion techniques may not be particularly essential for learning. What seems to be essential is if the important parameters and interactions are kept the "identical" between virtual and practical operation situations. Furthermore, this conclusion has to be further examined, especially if somebody concerns that the motion techniques applied in both operation modes are easy and have already been utilized by the learners before the college. For example, some questions need to be explored, like "Is the shift of the operation mode viable when the motion techniques included in the practical mode are complicated?", or "How earlier background with the virtual or physical operation motion techniques affect the effects of shift of the operation mode?"

Besides, the plan of researches in the future have to permit examining of hypotheses regarding the perceived modes actively utilized in the experimentation period, and how this application of perceived modes influence learners' cognitive load and combination of multi-mode messages. Factors, such as the participants' age or earlier disclosure to PoE by past experiences, also have to be examined. It may be the condition, for instance, that the students of the proposed research who utilize VoE do not require the perceived modes from touch because the messages are already in learners' long-term memory from earlier experiences in learning.

7 CONCLUSIONS

The findings of the proposed research offer messages regarding the possibility and merit of the utilization of VoE and PoE for learning hydraulics, especially of VoE that has been argued as a feasible mode for learning. The data of the proposed research in the quantitative and qualitative analysis indicate that the utilization of VoE enhanced participants' comprehension of hydraulics notions quite good as PoE, with the supply that VoE and PoE are performed inside a circumstance similar to the one of the proposed research. This result sustains the recent studies regarding the corresponding effect of VoE and PoE for enhancing learning in science (Klahr et al., 2007: Triona & Klahr, 2003; Zacharia & Olympiou, 2011). Another finding appear on the qualitative analysis in the proposed research's data that farther sustains the above disputation is that the greater part of the members in whole experimental situations reveal to share the identical notions in NANH, both in the pre-post tests. This result shows that the learning outcomes and the character of learning do not virtually change when PoE is substituted for VoE. This result offers farther mode to the concept that VoE can be utilized (in some circumstances) to offer reliable workshop experiences that are not virtually distinct to the means utilized when applying PoE.

The question is considered that the two experimentation modes should be selected when VoE and PoE provide the same usability for hydraulics learning by experimentation, as in the proposed research. Apparently, any of the VoE and PoE learning circumstances will do. Nevertheless, if an instructor needs to select between VoE and PoE other causes in addition to the usability of each of the two kinds of learning circumstances should be concerned. For instance, conditions of cost-efficiency, convenience, or security can be concerned. Klahr et al. (2007) proposed some of these "exterior" causes that an instructor can pondered. For instance, they disputed that VoE ordinarily occupies less space and takes less effort. Hence, it is easier than PoE in classroom management. They also indicated that they easy reproduction and circulation of VoE as another apparent benefit over practical engineering toolkits.

Despite there are several limitations included in this research, e.g. the time-scheme that was used regarding the data gathered, the findings of the proposed research still offer a number of useful information. Particularly, Results like the ones of this research challenge the already constructed criterions regarding experimentation in the hydraulics classroom, as we undergone it by PoE, in a way that demands a re-specification and reconstructing of experimentation to involve VoE. However, this call for reformation generates the demand for comprehending how PoE and VoE could be merged in instructing and learning action orders for hydraulics. Hence, it is imperative to expand the empirical groundwork by analogous study so as to base the aspects advocated in this research.

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Customised eTextbooks
A Stakeholder Perspective

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Abstract: In this article we present a reader's as well as an author's perception of customized eTextbooks. Customisation providers such as editors, translators and graphic designers were asked about their preferred model of compensation for their work by self-publishing eTextbook authors or publishers. Although the royalty model was preferred by authors, most providers prefer an upfront payment. The main goal of this paper is to assess the value that stakeholders put on customised content. A survey conducted in 2013 showed that readers are not willing to pay a substantial amount for customisation. Readers associate a high level of risk with purchasing a self-published eTextbook. Respondents considered a fair retail price for self-published eTextbooks should be a third lower than those distributed by publishing houses. However, current prices charged by renowned publishing houses for a typical post-graduate level textbook chapter (i.e., around US$ 8-9) are higher than readers (e.g., students) consider reasonable. Convenience is the major factor determining why people read eTextbooks and recommendations by peers and forum members rank top in creating awareness and influencing the actual purchase. The authors recommend a system based on collaborative filtering to provide customization options to readers.

1 INTRODUCTION

Customisation has spread to increasingly diverse areas such as creating one's own holiday by mixing and matching transportation, accommodations, restaurants and experiences, so no holiday needs to be the same. Other examples are: t-shirts (graphical design), M&Ms (text messages on sweets), own blend of tea or coffee, eyeglasses, golf clubs to name a few. One of the latest examples is the book market.

The global book market was valued in excess of US$120 billion in 2011 (Lucintel, 2012). Digital versions of books 'eBooks' are taking away market share from printed books, while reinventing the medium itself due to lower cost, easy distribution and digital functionalities. Fuelled by cheap distribution and low production cost, there is a continuously growing market of self-published eBooks. A sub-type of eBook is the eTextbook, mainly read by students and compiled by tutors (instructors). Whereas the printed hardcover textbook of a post-graduate course can amount to US$200 or more, the electronic version is offered, at best, for half that price. Most leading academic publishing houses offer customisation options. Instead of selling a complete textbook (e.g., 800 pages, 22 chapters), they offer chapters for around US$8.50 each. Tutors can pick the content they like and may add third party case studies, simulations or whatever they consider suitable. However, the more copyrighted materials the more expensive the customised eTextbook becomes.

Tutors are becoming more and more interested in customising their textbooks. Large academic publishing houses support this trend by offering customisation sites for their textbooks and provide instant gratification by offering instantaneous delivery of the compiled eTextbook. Besides large publishing houses there are intermediaries that negotiate license fees with various content providers on behalf of the self-publisher or buyer. Buyer could be a professor teaching a course or a whole university that wants to customise textbooks for their courses.

Self-publishers often rely on third party service providers such as graphic designers and animation developers. The starting point can be a text, to which other providers can add covers, layouts, edited versions, translations, etc. The eTextbook project initiator can decide to either own the content/design by paying a fixed amount to providers, or to work with other content providers on a royalty basis (Stommel and Bechter, 2013).

According to Goldberg (2011), self-published books outnumber traditionally published ones by 2 to 1, with more than 210,000 titles being self-published (based on ISBN statistics) each year. The growth rate of eBook self-publishing is a factor of four higher than printed book self-publishing (Rice, 2012). Self-publishing activities are estimated to have led to traditional publishing houses missing out on some US$100 million in revenue in 2011 (Rice, 2012). Self-publishing of eBooks is fuelled through an increasingly large number of service providers, with an increasingly diverse focus. The more the market matures, the more service providers have to specialise.

While the vanity aspect of being published instead of self-published is still a factor for some authors (Jia, 2012), this seems to become less of an issue for academic authors. Hence, according to some researchers, self-publishing will become the norm for eTextbooks (Goldberg, 2011).

Some authors recommend that tutors give away their self-published eTextbooks for free because royalties earned are only of secondary consideration for academics (Hilton and Wiley, 2010). For example, eTextbooks are already available at the Worldreader digital library, where African children have free access to such educational eBooks on their mobile phone or donated Kindles, initiated by David Risher, a former Amazon executive (Wingfield, 2012; Fowler and Bariyo, 2012).

Besides the obvious advantages of working with eTextbooks, self-published or not, there are disadvantages:

- Lack of universal publishing standards.
- Sharing/lending books becomes difficult without violating copyrights (Fister, 2010).
- Privacy might be impacted when personal text markings (shared on some reading platforms) are utilised by others (Fister, 2010).
- No bookshop support (Fister, 2010).
- No chance of becoming a collector's item (Jia, 2012).
- Issues pertaining to Digital Rights Management (Fister, 2010).
- Loss of income to authors because of piracy (Williams, 2012).

Usually, publishers grant licenses for a limited period of time (e.g., three years) and demand high sales (e.g., 200+) volumes. Especially students may complain that a used, customised eTextbook cannot be sold on to junior batches because of the customised content.

While a significant share of available eTextbooks are direct copies of print to the digital environment, partly in order to mimic the reading experience of a print book (layout, switching pages, etc.), some additional functions have already been incorporated (Alfa Bravo, 2011):

- Adding/sharing/seeing other student's notes
- eTextbook recommendation by email, Facebook, Twitter, etc.
- Online rating
- Text highlighting/copying
- Adding bookmarks
- Choice of fonts, font sizes and background colours
- Text search
- Usage on multiple devices
- Integration of animations, simulations and digital stories
- Integration of audio files (audiobook)

eTextbooks increasingly exploit the digital nature and include audio and video content, as well as hyperlinks and other interactive aspects. Examples are learning about chemistry (Swanson, 2011) and medical education (Husain, 2011) respectively. However, in most cases, these additional functionalities are often not yet compatible with eReaders, and can only be accessed on tablet computers.

Customisation is often supported by 'granulation' of creative efforts (Stumberger, 2012). A book project is split into very small components. Long term work contracts often make way for assignments, with individuals contributing their expertise for a very short period of time to such eBook projects involving a large number of individuals (Stumberger, 2012). From the author's point of view, benefits can be derived from a virtually unlimited source of providers, potentially located world-wide, with high speed interaction (Velamuri, 2012). On the downside, typical concerns are intellectual property theft and the missed chance of building competencies within the publishing house or the self-publisher her/himself.

It is difficult to get reliable data on the market share of self-published eBooks. Estimates for the U.S. market range from 30% market share of self-published eBooks to 77 % (McLaughlin, 2012). The revenue share of self-published eBooks is generally lower compared to the volume share, because self-published eBooks are lower priced than published ones.

The strong growth in eBook consumption has been propelled by widely available eReaders (e.g.

Kindle), tablet computers and smart phones, which – at the end of 2011 – enabled 807 million consumers around the world to read eBooks on their devices (Research and Markets, 2011). By 2015 this number is expected to grow to 1.8 billion unique users worldwide – this reach is roughly equal to the expected reach for daily newspapers (Research and Markets, 2011).

The most popular eBook formats are epub, kindle and pdf. By offering an eBook in all three formats, basically every available reader can process a copy of an eTextbook.

2 RESEARCH OBJECTIVES AND THEORETICAL FRAMEWORK

Since the eTextbook market is very young and dynamic, most recent information can only be found on the web. This leads to an overrepresentation of online sources compared to academic journals, which in some cases might result in overemphasising the point of view of individuals. For example, forum discussions are a good indicator of the latest developments in this very young industry, however, they often represent the convictions of single individuals only. The purpose of this study was to analyse the process of how eTextbook readers find / choose their next book and whether they had an interest in customisation and self-published books.

Apart from readers, the criteria of authors for selecting their self-publishing provider and the interest in customisation by outsourcing parts of the project were also analysed. Besides readers and author the third target group of the research were graphical designers, editors and translators. It has never been analysed whether such providers are willing to offer their services to a self-published eTextbook on a royalty basis and if for how much.

The research questions were:

- How does the eTextbook reading community perceive self-published eBooks versus the ones by renowned publishing houses?
- Does this community have an interest in customising their eTextbook?
- What is the community willing to pay for eTextbook customisation?
- How and on what motivational basis do self-publishing authors find and choose their self-publishing provider?
- What are the main perceived advantages and disadvantages of self-publishing eTextbooks for authors?
- Which aspects of eTextbooks – apart from the text – are the most crucial to the success according to authors and readers? What would be its monetary value?
- Are providers such as freelance graphical designers, translators and editors willing to work for self-publishing authors for royalties on sales? How high would those royalties need to be?

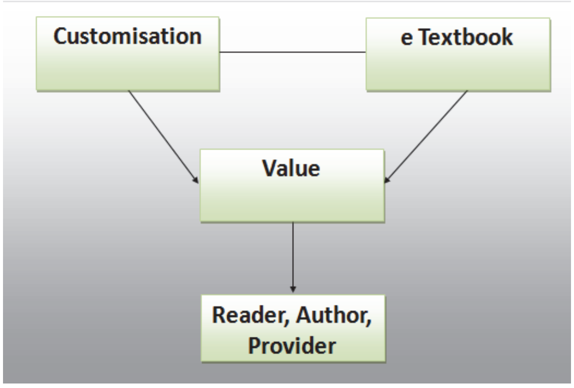

Figure 1: Research Framework.

The questionnaire addressing the value perception of *Readers* included 23 questions subdivided into 5 main categories:

1. Consumer reading habits and motivation: Time spent reading eBooks, type of eBooks, type of eReader and motivation for reading. From the various available motivational theories (Kotler et al., 2013), Maslow's theory was chosen as it is relatively straight-forward and lends itself better to online questionnaires (reducing the number of questions) compared to for example Hertzberg's theory (distinguishing between satisfiers and dissatisfiers).
2. Consumer psychology: The perception of self-published vs. published eTextbooks. Other stimuli for reading eBooks.
3. Marketing stimuli, buying decision process and purchase decision in regards to becoming aware of, finding and choosing eTextbooks.
4. Interest in customising written content and willingness to pay a premium for it.
5. Consumer characteristics: social, personal (demographic) and cultural parameters of the reader.

The questionnaire addressing *Author* issues included 25 questions subdivided in 6 main categories:

1. Introduction and author publishing history: the number of eBooks and the formats published in.

2. The publication motivation.
3. Publishing provider: How was the provider found and chosen, what are the business model preferences, what did the author learn from the collaboration?
4. Opinion/usage/pricing of (self-published) eTextbooks: analysis of author's perception on self-publishing and pricing.
5. Author's interest in add-ons to the written content and willingness to pay royalties.
6. Social, personal (demographic) and cultural parameters.

The third group, the *Providers,* were asked one question only concerning their willingness to provide building blocks to a self-published eTextbook without upfront payment, while participating in revenue sharing through royalties and stating her/his expected share of the cake. Because the largest social networks are not professional ones (e.g. Facebook, Myspace, Google+), these were deliberately not used as data source. Some of the reasons for this decision were:

- Too big a network can quickly lead to participants of lower relevant qualification and lower quality exchanges (Postrel, 2007).
- Niche social networks are often better suited to effectively reach the target market segments (Kotler et al., 2013).

Therefore, the author/provider questionnaires were posted in following groups, see Table 1.

Table 1: Questionnaire postings: authors and providers.

Network	Group	Members	Survey
Xing	eBook	~400	Authors
Xing	Überse	~5,000	Editors/Transl.
LinkedIn	LinkEd	~49,000	Editors
LinkedIn	ProZ.c	~28,000	Translators
LinkedIn	Freelan	~4,000	Transl./Designer

Readers were approached through twelve online eBook forums.

All in all 616 responses were received out of which 400 were readers, the rest was made up of authors, editors, graphic designers, and translators. The predominant age group was 41 to 50 years of age. 41% came from the USA, followed by UK and Germany.

3 FINDINGS

Findings are based on surveys of readers, authors, and providers such as translators, editors and graphic designers.

3.1 Readers

Most readers used a Kindle (54 %), Sony eReader (17 %), Kobo (7 %) or Apple portable device (7 %). The primary reason/motivation for reading eTextbooks is convenience,see Table 2.

Table 2: Motivation eTextbook purchase.

Scale: 1 (low) – 10 (high)	Mean	StDev
Convenience	8.8	1.62
Ease of storage	8.6	1.97
Size of library	7.8	2.18
Interactive components	3.2	2.51
Video/audio content	2.2	1.95
Adjustable font (size)	7.7	2.19

Gender differences for the parameters listed in Table 2 were evaluated through mean differences. A t-test indicated significant differences for 'Convenience', 'Ease of storage' and 'Adjustable font size', which were significantly higher ranked by women. When comparing the expected price difference for published vs. self-published eBooks, all respondents expect the same or a lower price for the self-published eTextbook, with the median at 45 % i.e. 45% price deduction for a self-published book, see Figure 2.

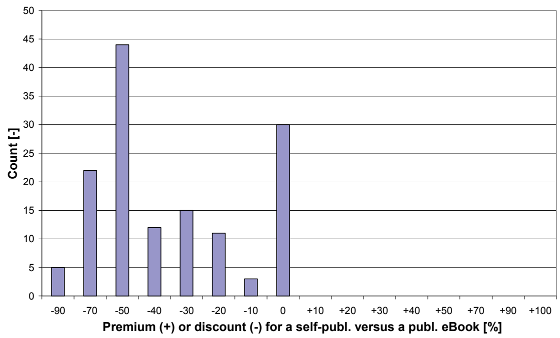

Figure 2: Price perceptions.

The main reason for the expected discount is the perceived risk of poor quality when buying a self-published eTextbook. To check for interdependence between the discount and other reasons than risk for the expected discount (e.g. lower production cost, lower overhead, less marketing expenses), a cross tabulation was carried out, followed by a calculation of Lambda coefficient and Goodman and Kruskal tau in order to test the strength of the associations. Both statistics showed no association between expected discount and other justifications.

The next questions were: how do readers become aware of these self-published eTextbooks and what additional electronic features do they expect and how much more are they willing to pay?

Table 3: Awareness sources.

		Mean	Stand. Dev.
Online ad		3.9	2.65
Information in article		5.3	2.42
Online posting by author		4.1	2.74
Recommendations from friends / in forums		7.9	2.23
Book seller recommendations based on prior readings		5.4	2.76
Book seller homepage recommendations		4.3	2.61
Browsing by topic on book seller homepage		5.5	2.81
Browsing by price on book seller homepage		3.9	2.72

Recommendations by friends and forums were the most important factor when becoming aware of a new eTextbook, see Table 3, as well as actually purchasing it, see Table 4.

Table 4: Buying criteria.

		Mean	Stand. Dev.
Forum/friend recommendations		8.0	2.10
Book seller recommendations		5.1	2.55
Readers' reviews		6.8	2.17
Cover		4.9	2.51
Price		6.3	2.60
Sales rank		3.6	2.60
Blurb/book summary		7.3	2.19
Reading sample		6.8	2.97

Blurb and a reading sample ranked second and third.

Readers were given seven customisation options which they had to rank between 1 (lowest interest) and 5 (highest), see Table 4.

Average interest in any of the given customisation options was low, with the choice of book cover ranking highest. As a direct result, the premium that the respondents are willing to pay for customisation options is relatively low ranging from US$0.06 to maximum US$0.13 (adding personalised content). Respondents who were interested in a choice of book cover, were as well interested in a choice of graphics and choice of layout versions, see Table 6.

Table 5: Customisable features.

		Mean	Stand. Dev.
Animations		1.5	1.51
Choice of book cover (based on content)		2.8	2.58
Choice of graphics intermixed with text		2.5	2.33
Choice of edited versions (short/long)		2.3	2.13
Choice of layout versions (e.g. gothic, fairytale, modern, …)		2.5	2.24
Adding of digital stories		2.1	2.10
Adding of personalised content		2.4	2.36

Table 6: Customisation Options Correlations.

		Cover	Graphics	Layout	Age
Cover	Pearson Corr.		.607**	.536**	-.209*
	N	140	140	140	138
Graphics	Pearson Corr.	.607**		.483**	.195*
	N	140	140	140	138
Layout	Pearson Corr.	.536**	.483**		.194*
	N	140	140	140	138
Age	Pearson Corr.	-.209*	.195*	.194*	
	N	138	138	138	138

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

No association between customisation options and gender was found. In order to reduce the number of answers/variables, a factor analysis of the questions with numerical scale was conducted. Table 7 shows that ten variables can be condensed into four factors (also known as components or dimensions). Factor one can explain the most (22%) and factor 4 the least (12%) of variance.

The four factors can be described as follows:

1. The first factor has four high loading variables (cut-off : 0.6) and can be described as valuing the ‘easy to use’ characteristics of eTextbooks.
2. The second factor has two high loading variables and can be described as valuing the ‘interactive’ characteristics of eTextbooks.
3. The third factor has two high loading variables.

The dimension can be described as 'sales price' dimension.

4. The fourth factor reflects the 'discount' that a self-published eTextbook comes with.

Convenience in the broadest sense is the main reason. Second reason reflects the additional interactive features that eBooks offer.

Table 7: Major Factors.

	Factor Loadings			
	1 (22%)	2 (16%)	3 (15%)	4 (12%)
Ease of storage	0.779	0	-0.10	0.014
Size of library/modules/chapters	0.730	0.017	-0.21	0.172
Convenience	0.666	0.035	0.158	-0.2
Adjustable font	0.636	-0.06	0.148	-0.09
Reading time	0.478	-0.31	0.031	0.202
Interactive components	0.069	0.892	-0.01	0.001
Video/Audio content	-0.14	0.852	0.148	0.126
Price published eTextbook	0.057	0.009	0.896	-0.25
Price self-publ. eTextbook	-0.03	0.17	0.806	0.464
Discount self-publ. eTextbook	-0.01	0.069	-0.02	0.932

3.2 Authors

A total of 90 authors answered the questionnaire. The predominant age group was 31 to 65, see Figure 3.

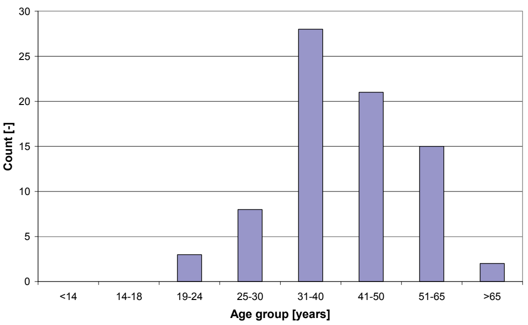

Figure 3: Age distribution authors.

When asked about their motivation, income seems the main driving force to write eTextbooks, see Table 8, but self-development in the sense of Maslow's motivation theory ranked a close second.

One can hypothesise that the more global exposure of an eTextbook the more income can be generated through royalties or revenue when self-published. This was confirmed by our research finding, see Table 9.

Table 8: Authors' Motivation.

	Mean	Stand. Dev.
(additional) Income	7.3	2.73
Peer pressure	1.3	1.24
Self-esteem	5.1	3.28
Recognition by others	4.3	2.98
Status	3.4	2.46
Self-development	7.1	3.05

Table 9: Why author eTextbooks?.

	Mean	Stand. Dev.
eTextbooks are the future	8.0	2.23
eTextbooks are cheaper to produce	8.9	1.82
eTextbooks give global access	9.1	1.65
eTextbooks are interactive	5.2	3.30
eTextbooks come with video/audio content	4.6	3.40
eTextbooks give a better chance of success	8.5	2.29

When asked to assign a fair selling price to one of their own eTextbook chapters, the average was US$3 or 25% lower than the readers are willing to pay. However, the authors think in terms of income and the readers in terms of retail price (incl. VAT) so both are not too far apart.

The preferred compensation model of working together with service providers was on a royalty basis (82%) versus upfront payment. When it came to the question how authors chose their current publisher, the distribution reach ranked highest. The amounts they are willing to share are relatively small, see Table 10.

Table 10: Authors' Royalty Model.

in US$	Mean	Stand. Dev.
Cover	0.25	0.22
Graphics	0.16	0.18
Editing	0.26	0.21
Layout	0.17	0.17
Translation	0.26	0.25
Digital Stories	0.21	0.32

On average translation ranked highest, a fact that is down to non-English speaking authors. Assuming that an eTextbook gets sold 10,000 times then US$2,600 would go to the translator.

3.3 Providers

Nineteen graphical designers took part in the survey. Only a third of respondents would consider providing a cover based on a royalty model. The ones who did, consider around US$1 as a fair share for their contribution to an eTextbook, a far cry from the US$0.16 per book that authors consider as appropriate. Out of the twenty five editors who participated only 25% consider the royalty model as fair. The few who would settle for it consider around US$0.70 as fair share. 56 out of 82 translators were not willing to contribute without upfront payment and 8 would consider this on a case by case basis. Royalty expectations are in the region of US$1.50 per eTextbook chapter.

In conclusion, providers ask for more than authors and readers are willing to pay. However, it has always been difficult to evaluate the willingness to pay. Most people underestimate their propensity to buy. In this context a conjoint analysis may yield more reliable results and can be scope of further research.

4 CONCLUSIONS

The eTextbook reading community finds its next read through recommendations of friends and in forums. Self-published books should be priced at a 45% discount. Generally, eTextbook readers are not willing to pay a significant amount of money for any type of customisation. Convenience is the main factor why people buy eTextbooks. This may explain why customisation is not considered a major value-added feature. The moment a reader has to think about customisation, the convenience suffers. A compensation model based on royalties will work for authors but not for service providers.

5 IMPLICATIONS

Focusing on instructors, publishers have to take the initiative and offer customisation services. Otherwise they risk that tutors/instructors offer their textbooks in form of self-publishing and may even give it away for free. The eTextbook customisation itself can be done in-house or outsourced through a straight buy or on royalty basis. Tough negotiations between self-publishing authors on one side and graphic designers, translators, editors on the other side can be expected.

Asian students may want digital stories dealing within an Asian context whereas Europeans may go for their cultural setting. In a more formal approach this can be done in two ways. The first technique is content based filtering (Pazzani, 1999). This filtering technique could, for example, suggest book covers, layout formats etc. to readers based on a set of eBooks in which readers have expressed interest or bought in the past. Collaborative filtering (Konstan, 1997), the second method, is making automatic predictions (filtering) about interests/preferences of a reader by collecting information from many other *neighbouring* readers.

Collaborative Filtering systems usually take two steps: Firstly, look for readers who share the same patterns with the user. Secondly, use the ratings from those like-minded neighbours found in step 1 to calculate a customisation prediction for a specific eTextbook reader/customisation and his/her willingness to pay a certain amount for it.

$$P_{a,i,k} = \rho_a + \frac{\sum_{u=1}^{n} (r_{u,i,k} - \rho_u) * w_{a,u}}{\sum_{u=1}^{n} w_{a,u}}$$

$P_{a,i,k}$: prediction for reader a for customisation feature i under a given price k

n : number of neighbours u

$w_{a,u}$: similarity weight between reader a and u

$r_{u,i,k}$: rating neighbour u for customisation feature i under a given price k

ρ_a : average rating reader a

ρ_u : average rating reader/neighbour u

The likelihood that a reader is willing to pay for a certain customisation feature (e.g. a personalised digital story) can be calculated according to above formula. It depends on the reader's general disposition i.e. some readers want to have any possible customisation, others are more cautious. The prediction whether reader a likes customisation i is based on his/her neighbours. The similarity index $w_{a,u}$ is a simple correlation.

In the era of digitalisation, customisation can easily be done as demonstrated. Surprisingly, no publisher has seriously pushed it yet. Offering book chapters and case studies as modules lacks the potential that custom eTextbooks offer, even more so when they come at a deterring price.

Another media industry that went through a similar experience is the music industry. Nowadays, most money is made by selling merchandise and concert tickets and not by music recordings itself. Some artists even post their songs for free on sites like Youtube and make money through advertising. A real game changer could be the eTextbook because it engages students and tutors. Although lacking the traditional administrative backend of a LMS, an eTextbook can offer a wider variety of interactive features and choice of devices. Publishers have been offering eTextbooks in the form of course content integration but not as LMS in its own right. Especially in the context of blended learning, where a physical infrastructure and administration system already exists, the drawback of a missing backend can easily be overcome. Both, LMS providers and publishing houses commit to 'doing the things right' by adding more and more technical features to the LMS and publishing more and more textbooks in prevailing eBook formats. The real mantra, however, should be 'doing the right things' by delighting customers – the students. Students love their mobile phones that enable them to access all sorts of information, from friends to lectures. This is a major advantage of m-learning. Since publishing houses, universities and LMS providers are not necessarily known for delighting customers or embracing disruptive innovations, it may be self-publishing eTextbook authors who will the first to provide engaging m-learning (Bechter and Stommel, 2014).

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The Nature Tour Mobile Learning Application
Implementing the Mobile Application in Finnish Early Childhood Education Settings

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Keywords: Early Childhood Curriculum, Mobile Learning, Mobile Learning Framework, Outdoor Learning.

Abstract: This paper explores the implementation of the Nature Tour mobile learning application in Finnish early childhood education settings. The interest is to explore whether the concept of Nature Tour mobile application meets the needs of early childhood education in field trips. The idea of the mobile application is to help recording and comparing nature observations as well as to arouse children's interest in nature. The feasibility of the mobile application was evaluated through a theoretical framework, which includes the core aspects of mobile learning. The evaluation framework consists of two levels titled core level and medium level. Three of the core level aspects were realized well. These aspects were the aspect of context, time and space. The medium level aspects that were realized well were social aspect and learner aspect. While the device aspect was a slightly more challenging as the Nature Tour mobile application required literacy skills and therefore it required adult guidance. The study indicated that the technology use in the early childhood settings evidently requires balance between the curriculum, children's needs, human interactions, as well as technological and pedagogical support for the effective use of technology.

1 INTRODUCTION

The presence of media and technology has become extensive and ubiquitous in Finnish children's lives and the children usually learn to use media and technology at the very early age (Suoninen, 2010). Since the media and technology are so closely intertwined with children's everyday life, integrating those into curriculum can be an effective way to engage children in learning activities.

During recent years, the potential of mobile technology for enhancing and diversifying learning has received increased attention. Earlier studies have indicated that mobile technologies can enhance natural science and outdoor learning in many ways. For example, mobile technology can arouse children's interest in nature. In particular, technological tools can provide new choices and more flexibility for personal expressions and learning for children (Blagojevic & Thomes, 2008). Especially the benefits for study motivation and learning achievements are highlighted (e.g.,Tan, Liu and Chang 2007; Chen et al. 2008; Hwang, Shi and Chu 2011). Also considerable changes in teacher teaching and student learning have been reported (Zhang et al., 2010). According to Huang et al. (2010) mobile technologies and an outdoor learning strategy are very useful tools when teaching children about plants. However, many researchers are mainly studying primary and secondary school students and there are only a few studies that are focusing on children under school-age (aged 5-6 years).

This paper explores the implementation of so-called Nature Tour mobile application in Finnish early childhood education settings. The feasibility of the developed mobile application was evaluated through a theoretical framework, which includes the core aspects of mobile learning (such as the aspect of context, time and space, device aspect, social aspect and learner aspect). In this study, the interest is to explore whether the concept of Nature Tour mobile application meets the needs of early childhood education in field trips. The data was mainly collected with the teachers' group interview. The study is part of a larger research where the aim is to develop both a theoretical framework for mobile learning as well as tools and practices for the use of mobile technology for teaching and learning at different levels of education.

Finland has a national curriculum that provides guidelines on early childhood education, but municipalities and the local authorities have the freedom to decide how early childhood education is organized (Stakes, 2003). Mobile technologies have made inroad in educational contexts little by little in Finland too, but unfortunately early childhood authorities and educators are not early adopters of these kinds of new technologies, even though mobile technologies could create new opportunities to early childhood education as well. This paper aims to highlight some of these opportunities.

In the following section, the mobile learning framework is presented with the focus on mobile technologies in outdoor learning. After this, the mobile nature tour application and Finnish early childhood education as the context of this study are described. The paper continues with the sections of the research design, results and finally, concludes with reflective remarks and proposals for the future research.

2 MOBILE LEARNING FRAMEWORK

This study has adopted the mobile learning definition given by O´Malley et al. (2005) "any sort of learning that happens when the learner is not at a fixed predetermined location or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies" as it highlights that mobile learning is not merely about learning by using mobile devices, but also learning across different contexts.

One of the main aims of this study is to further build the theoretical framework for mobile learning (Rikala, 2013). The framework advances the two most recent theoretical frameworks (Koole, 2009 and Kearney et al., 2012), that suggest that mobile learning has certain elementary characteristics that separate it from other types of learning. The current framework consists of two levels (see Figure 1.) titled core level and medium level. The core level and medium level are shortly explained as follows. The mobile technologies have the unique ability to support learning anywhere and anytime. For example, they can expand the learning environment to authentic contexts such as parks, museums, and nature. Therefore, the aspects such as context, time and space form the core level of mobile learning.

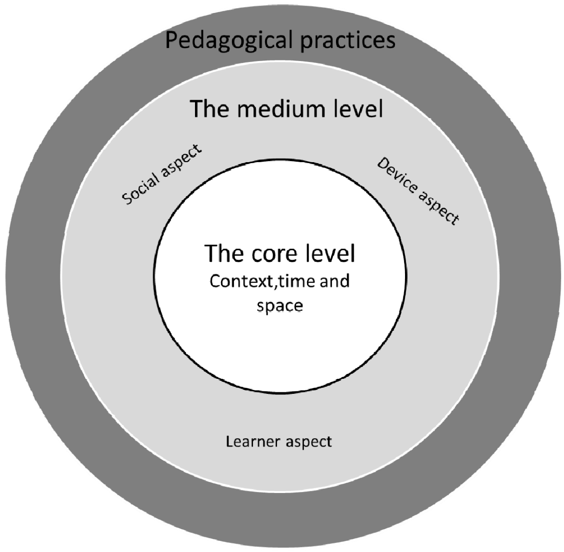

Figure 1: The Mobile Learning Framework.

The medium level comprises the other important aspects in the mobile learning process, which are the learner aspect, device aspect, and social aspect. The learner aspect refers to an individual learner's cognitive abilities, memory, emotions, possible motivation, attitudes, and experiences, which are in a significant role in the learning process and thus mobile learning process as well. In the device aspect the physical, technical, and functional characteristics of a mobile device are emphasized as they are important factors of the device usability. The physical, technical and functional characteristics include input and output capabilities, storage capabilities, power, processor speed, compatibility, and expandability. These characteristics influence the device usability which in turn influences the learner's experience, perceived ease of use, and perceived usefulness. The social aspect, in turn, is associated with the processes of social interaction and cooperation. For instance, the philosophy of social constructivism views learning as collaborative and it emphasizes social interactions. Thus, the impact of interaction on learning cannot be underestimated. (Koole, 2009)

The pedagogical aspect (i.e. pedagogical practices) was also added to the evaluation framework. The earlier mobile learning pilot tests have indicated that the pedagogical aspect is one considerable aspect (Rikala and Kankaanranta, 2012).

In this framework, the learner aspect can be realized by ensuring that the learner's needs are taken into account, whereas the social aspect can be realized by ensuring that the learners can exchange information and collaborate. The device aspect should be taken into account when planning the mobile applications as well as when planning the mobile learning activities. Pedagogical practices and especially the activity design, in turn, influences on the core and medium level aspects and how those are realized. In this study, these aspects provide an evaluation framework in which the feasibility of the Nature Tour mobile application is analyzed.

3 OUTDOOR LEARNING MEDIATED BY MOBILE TECHNOLOGIES

Outdoor education is widely recognized as the most feasible method of teaching the phenomenon of the natural world (Tan et al., 2007). Nonetheless, the field trips can be physically and mentally challenging and sometimes difficult to fit in educational situations (Bedda-Hill, 2012). However, the experiences and quality of outdoor education can be enhanced with information and communication technologies (Osawa et al., 2007).

The core level aspects (context, time and space) can be fulfilled with mobile technologies. For instance, mobile systems can enable learning with the learner's own preferred route and speed (Shih et al., 2011). Real-life observations conjoin with access to digital technology and contents can help learners to make distinctions for example between the plants in authentic context (Shih et al., 2011). Thus, at the best learners can learn anytime and anywhere so learning can be very personalized, situated and authentic. This kind of spontaneous use has been raised as one of the core features of mobile learning in many mobile learning studies (e.g., Traxler 2005).

The learner aspect can be fulfilled in many ways. Firstly, the mobile devices can support, guide, and extend the learner's thinking process within and out of the classroom (Chen et al., 2008). Secondly, the mobile systems can improve learner creativity as well as ability explore and absorb new knowledge as well as solve problems in different locations (Tan et al., 2007). Thirdly, when learners are using mobile devices they can express their own perspectives more freely (Shih et al., 2011). Fourthly, as the mobile systems can enable learning with the learner's own preferred route and speed, and can support and guide the learner' thinking process, the learning can be more independent and self-reliant (Chen, Kao and Sheu, 2003). For these reasons mobile technologies can have positive effect on the involvement and motivation (Huizenga, Hordijk & Lubsen, 2008). Hence, outdoor learning could be more enjoyable and challenging for learners.

Also the social aspect can be fulfilled as the mobile systems can encourage social interaction. Huang et al. (2010) for instance argue that the mobile technologies can stimulate students to engage enthusiastically in assigned outdoor learning activities, as well as stimulate social interaction and discussion about course material.

The device aspect should be taken into account when planning the mobile applications as well as when planning the mobile learning activities as the device usability influence the learner's experience, perceived ease of use, and perceived usefulness. When the device is comfortable to use it can help to reduce learner's cognitive load and increase task completion rates as the learner is able to concentrate on the activity rather than the mobile device. (Koole, 2009)

Based on the literature review, mobile technologies can enhance natural science and outdoor learning in many ways. However, there are only a few studies that are focusing on children under school-age (aged 5-6) which increases the significance of the present study.

4 THE NATURE TOUR MOBILEAPPLICATION

The Nature Tour mobile application was developed and implemented as a part of the Personal Mobile Space project (during the years 2009-2012) in the University of Jyväskylä, Finland (see Kankaanranta, Neittaanmäki and Nousiainen, 2013). The Nature Tour mobile application is developed especially considering the early childhood and lower primary education settings. The idea for the application was based on the demands of the day care experts.

The primary objective of the developed Nature Tour mobile application is to enhance children's outdoor learning experiences by helping the documentation of the field trips. Continuity of the learning experience is promoted with activities before and after the field trip. Before the field trip, children can familiarize themselves with plants, animals or fungi as the mobile application is associated with a web page which contains relevant information. After the field trip, the children can view the recorded observations and for example create stories. The idea of the web page is also to enable the comparison of what species or

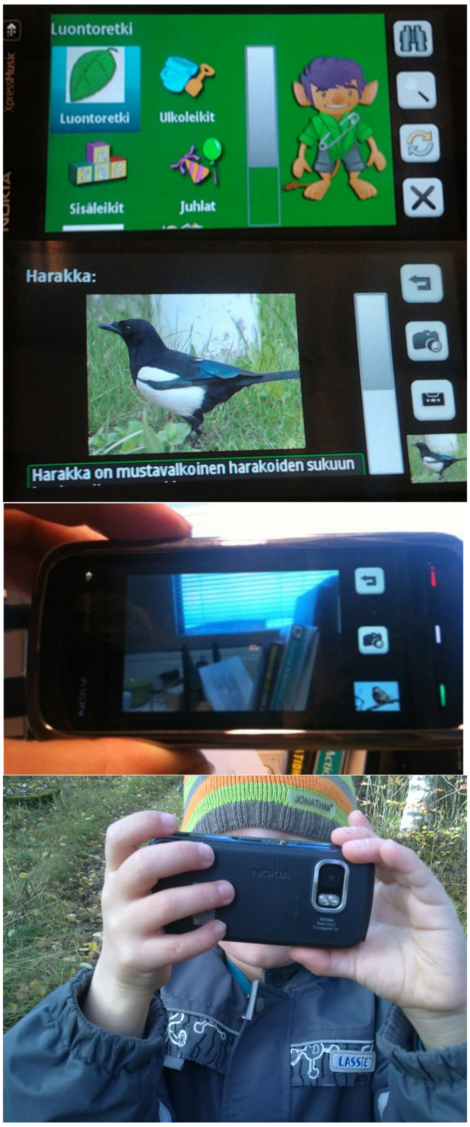

Figure 2: The screen captures of the application (the opening view, relevant information about the species, taking a photograph, and child recording observation).

phenomena have been observed across the country. For example, one group from southern Finland and another group from northern Finland can record their observations and make comparisons.

The function of the developed mobile application (see Figure 2) is to help recording observations during the field trip. The mobile application allows the user to save observations with photographs or with audio recordings and to send these recordings to the web page, where they can be viewed later on. The main categories of the Nature Tour mobile application (in the opening view) are Nature Tour, Outdoor Plays, Indoor Plays, and Celebrations. The nature tour category is used for the nature observations during the field trips. Other categories allow the wider use of the mobile application in daily life.

The nature tour category includes subcategories such as animals, plants and fungi. Each of these categories opens up a list of the species as well as small pictures. By choosing the species, the user can have relevant information (e.g., picture and core information) about the species and can record observations. For instance, a child can take a picture of a plant or try to record bird's chirping.

The mobile application requires the ability to read and for that reason it requires adult guidance. Hence, the application is designed to provide concrete experiences in nature with the guidance of an adult inasmuch as it is important that the educator describes and explains situations.

5 EARLY CHILDHOOD EDUCATION IN FINLAND

In Finland, the compulsory primary school starts usually at the age of seven and the early childhood education concerns children under school-age. Therefore, the preschool is considered a part of early childhood education and it is intended especially for six-year-olds but it is voluntary. (National Board of Education, 2000)

The national curriculum gives guidelines on early childhood education, but municipalities and the local authorities can decide for themselves how early childhood education is organized (Stakes, 2003).The core of the learning in Finnish early childhood education is the interactions between children, adults and the environment rather than accurate contents. Hence, nature and the immediate neighbourhood are considered the important elements of the learning environment. (Ministry of Social Affairs and Health, 2004)

All the themes, phenomena and contents covered with should be linked to children's immediate environment, daily life and concrete experience. For instance, animals and plants can be located in children's immediate environment indoors and outdoors. For example, modern information technology offers possibilities to create and share contents in different contexts. (Stakes, 2003)

The early childhood educator's role is to set up the fertile activities and learning environment for the children where the information technology can be one component but not dominating. It is important to find the right balance as technology cannot replace human interactions or relationships. The successful integration also requires educator's knowledge about learning as well as knowledge of how to integrate technology into the curriculum to meet the needs of children.

New creative media and information technology in early childhood settings is a quite seldom used in Finland. There are some projects funded by the Finnish national board of education (e.g., Molla project) which aims to bring updated information and action models to people implementing media and information technology such as iPads at pre-school education. The first findings of the Molla project are indicating that media and technology can enhance children's learning. Differentiated learning materials can serve children with different learning needs (the learner aspect). The mobile technologies such as tablet devices also give the children opportunity to perform tasks together which encourages interaction (the social aspect).

6 THE RESEARCH DESIGN

This is a case study that examines the feasibility of the Nature Tour mobile application in the context of specific early childhood education in Central Finland. The research included two parts: one short-term pilot test in the spring 2012 and one longer-term implementation in the autumn 2012. The use of a case study method is appropriate because it provides in-depth examinations and gives understanding of perspectives, opinions, and expectations of the smart phone usage and application.

The short-term pilot test provided guidelines for the further development of the mobile application and ideas for the longer-term pilot test. The short-term pilot experiment was entirely research-led activity involving observations as a research method. Eleven children and one teacher were participating in the field trip which duration was three hours. At the end of the field trip, the teacher stated that she is voluntary to continue the experiment in the autumn.

In the longer-term experiment two early childhood education groups were participating. Total of 29 children, two teachers, and one assistant were participating for two months. They used loaned smart phones which were preinstalled with the prototype of the nature tour application. The teachers were able to use the application independently and could plan the activities by themselves. The researcher provided a short orientation session for the teachers but otherwise the teachers worked independently. The mobile applications were used in appropriate situations. The teachers' and assistant's feedback about the mobile application was collected after the experiment with a group interview. The interview covered the core level and the outer level aspects, as well as the pedagogical aspect.

7 THE RESULTS

The feasibility of the Nature Tour mobile application was evaluated through a mobile learning framework (see Figure 1). The core level aspects, medium level aspects as well as pedagogical aspect are described in the following chapters.

7.1 The Core Level Aspects

The context where the Nature Tour mobile application was mainly used was field trips but the teachers also reported that they used it within doors and when they were documenting the phenomena of the first snow. Hence, the learning was applied appropriately in real-world contexts. The teachers reported that the Nature tour mobile application extended learning beyond the traditional learning space (i.e., classroom) in a motivating way. Both teachers reported that they organize several field trips for their groups during the year. The field trips so far, however, have been less structured (e.g. the children have been able to play and build huts). The teachers argued that the device and related instruction clearly directed the children's attention to nature.

The frequency of the application use was not very high. One of the teachers reported that she used the application three times with her group and the other teacher reported that she used the application several times but not every day. According to the teachers the use of the application was not specifically designed, but instead the activities were rather spontaneous situations. The children were able to take pictures without restrictions. However, the time when the application was used, in other words field trips, were arranged according to the schedule. This was mainly due to the fact that the equipment was loaned and the fact that the pre-school groups have plenty of other activities during the autumn. Hence, unfortunately the implementation was not as spontaneous as it at the best could have been. At the best, a child could use the application whenever the need arises (e.g. when a child sees the first flower of spring).

7.2 The Medium Level Aspects

The device aspect was slightly challenging as according to the teachers there were various technical problems during the experiment which were difficult to solve alone. These encountered problems reduced the teachers' desire to use application. For this reason the teachers experienced the application difficult to use and this also led to the situation where the children were not able to use the application independently. This finding indicates that the device usability strongly influences the experience, perceived ease of use, and perceived usefulness. The teachers stated that the mobile application should be simplified more. As such, the application contains too much content and requires literacy skills. Pictorial information would be sufficient for children under school-age (aged 5-6 years). In Finland children start compulsory school at age of 7 and the majority of the children learn to read during their first school year. Because the application required literacy skills the teachers thought that they had to open the application to the state where the child could take pictures. The teachers however believed that the children could learn the use of the application very quickly and added that they simply did not have the adequate skills to guide children to use the application appropriately. These findings indicate that the teachers' need sufficient technological support for the effective use of technology. The Nature tour mobile application could also be further developed so that even small children would be able to use it easily (e.g. by adding voices, pictorial information). The application could be further developed in such way that it could enhance children's literacy skills at the early stages. In other words, at the best the Nature Tour mobile application could work as a tool for acquiring literacy skills.

The learner aspect was realized well. The teachers reported that the mobile device brought an inspiring and motivating element for the children. The mobile application inspired children to look at their surroundings in novel ways. They observed surroundings and tried to find interesting places and things to be photographed. The children's creativity was reflected in the pictures as some of the observation pictures were very imaginative and artistic. These findings conform to those of previous studies that have indicated that when children are using mobile devices they can express their own perspectives more freely and that mobile systems can improve creativity and ability to explore and absorb new knowledge (e.g. Tan et al., 2007; Shih et al., 2011). The teachers mentioned that the children had never paid as much attention to nature as during the experiment. The mobile application therefore opened up a whole new world for the children and they began to construct knowledge and awareness of nature. One of the teachers commented: "The children observed nature more closely. For instance, they noticed the flowers: "Hey! Here are still growing some flowers. I will take a picture." Normally, probably, no one would even notice the flowers." The mobile application clearly offered the children new perspectives.

Also the social aspect was realized well. The teachers reported that the children observed the nature and paid attention to plants, fungi and other interesting nature phenomena and creatures. Some of the children even tried to identify the species independently and all the children were eagerly asking for the names of the species. The mobile application clearly encouraged social interaction with adults and with peers. The teachers reported that the children compared pictures with each other and gave the tips where they could take fine pictures. The children also interacted with the teacher by asking the species. The social aspect is one of the significant aspects because technology cannot replace human interaction or relationships. Especially in early childhood education human interactions and relationships are crucial as with them a child learns how to act and express oneself with an appropriate way in different situations (National Board of Education, 2000). It was encouraging to find out that the Nature Tour mobile application stimulated interactions.

7.3 The Pedagogical Aspect

The teachers highlighted that they did not know how to integrate the use of the application in daily life and other materials. One of the teachers commented: "The fact is that we already have plenty of material what we are using here. If something new is brought and it is just in a way "glued" top of all that, it does not integrate easily especially if you are not technically skilled. I think that this is the biggest challenge in our case." The lack of necessary skills to integrate the mobile application in the daily life was the main reason why the use of the application mainly remained a tool for photographing various things. The teachers mentioned that they just went to the field and took some pictures. The teachers considered that the use of the application and the follow-up activities should be planned in a more detailed manner and should be integrated into certain topics. In other words, there should be a clear pedagogical objective for each field trip. One of the teachers commented: "If we started to use this application, then it would require more detailed planning."

The difficulty of integrating the use of the application to other activities mainly was due to lack of necessary skills. The teachers did not have adequate knowledge about how to best integrate technology into the curriculum as the technology use in early childhood education in many places is a novelty or a seldom used. The teachers highlighted that the use of information technology cannot become a part of daily routines until the teachers have adequate training. The teachers' education was brought up and highlighted in the conversation. This finding is consistent with Mohammad and Mohammad (2012) who argued that successful integration requires educator's knowledge about learning as well as knowledge about how best to integrate technology into the curriculum. This clearly indicates the need for sufficient support (technological and pedagogical) for the effective use of technology.

8 CONCLUSIONS

The aim of the present study was to explore the implementation of the Nature Tour mobile application in Finnish early childhood education settings. The feasibility of the developed mobile application was evaluated through a framework, which included the core aspects of mobile learning. In this study, the interest was to explore whether the concept of Nature Tour mobile application meets the needs of early childhood education in field trips.

The present experiment indicated that the application has a lot of potential but also some major challenges. The experiment indicated that the application is quite easy to take into use and that it provides children tangible, motivating, and educative experiences in nature. The Nature Tour mobile application also encouraged social interactions with the adults and with the peers. The device aspect, in turn, was a slightly more challenging as the application required literacy skills. Hence, the guidance and the role of the adults were significant. On the one hand, the relationships and interactions with adults are important as the adult can guide children's observations and teach them how to act in different situations. Nevertheless, on the other hand, it would reduce teacher's workload if the children were able to use the mobile application more independently. For this reason the experiment indicated that as such the mobile application is not yet suitable for early childhood education settings but it has a lot of potential. Pictorial information would be sufficient for children under school-age (aged 5-6 years) who do not have literacy skills. The next step is to adapt the Nature Tour mobile application considering the discoveries and the feedback from the teachers.

One very significant observation was that the pedagogical aspect is very important. Based on the present findings it seems that the appropriate way to utilize mobile applications in early childhood education settings require the balance where technology use is matched with the curriculum, the children's needs, and human interactions. The technology use in the early childhood settings also requires sufficient support, in particular because the new creative media and information technology in early childhood settings still is a quite seldom used.

The experiment also brought out one major challenge: to promote mobile learning in early childhood education settings requires considerable change in teacher training as well as teachers' and policy-makers' attitudes. Therefore, the teachers' and policy-makers' attitudes should be investigated in more detail. Do the attitudes affect the way in which early childhood education is organized? Are the attitudes obstacles to the diffusion of technologies such as mobile technologies in early childhood education settings?

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Teachers Can Be Involved in the Design of Location-based Learning Games

The Use of the Puzzle Board Metaphor

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Keywords: M-learning, Game-based Learning, Puzzle-based Games, Location-based Games, Instructional Design Strategy, Game Design Task.

Abstract: Recent research in the Game-Based Learning domain shows that location-based games can lead to positive effects in students' motivation and engagement. However, the potential effectiveness of these approaches depends on to what extent their design is aligned with the requirements of specific educational situations. For this reason, involving teachers in the design of their own location-based learning games becomes crucial to fulfil their teaching requirements. This paper presents a metaphor based on puzzle boards as a technique to involve teachers in the design of their own location-based games. A design-based research methodology has been followed to evaluate the proposed metaphor. Previous research experiments have shown the feasibility of the puzzle-based games approach to allow secondary education teachers the design of these types of learning experiences. However, some issues in terms of understanding specific elements of the proposed metaphor were detected. A second iteration of the research methodology is described in the paper to evaluate the changes made to the definitions of the metaphor's elements and the dynamics of the game design task. The evaluation is carried out with 20 primary and secondary education teachers who completed a paper-based design task. The main findings show that teachers did not have problems using the proposed metaphor and they successfully designed their own location-based learning games.

1 INTRODUCTION

Over the past few years, handle devices have enabled learning situations that were hindered in the past by time and spatial limitations (Jones and Jo, 2004). These mobile technologies have brought the possibility to enhance learning and promote the creation of situated learning activities. In fact, mobile learning (m-learning) is an emerging field of educational research that is starting to attract the interest of practitioners in all phases of education to facilitate learning in informal settings within formal educational contexts (Bachmair et al., 2010). Most of these m-learning activities are characterised by integrating elements based on games (Bohannon, 2010). This leads to the creation of location-based games (Davis, 2002), based on mobile technology to implement pervasive and ubiquitous experiences.

Location-based games bring opportunities to: create learning experiences that involve exploration and cooperation (Hwang et al., 2008); access to contextualized information, communication, analysis and interrelation of real place (Roschelle, 2003); entertain and increase students' motivation towards learning (Davis, 2002; Yatani, 2004).

In order to create meaningful location-based learning games, it is important that they are aligned with the requirements of specific educational situations. In this line, it becomes crucial to involve teachers in the design of game-based learning activities (Tornero et al., 2010). However, teachers are faced with the difficulty to set these approaches so they fit into the educational process and the accomplishment of the pursued learning objectives (Tornero et al., 2010; van Rosmalen et al., 2011). Besides, the support by teachers is not straightforward, and the limited experience of teachers severely reduces the amount and quality of feedback a learner might receive. In this line, providing scaffolding strategies could be significant to foster the involvement of teachers in the design and implementation of their own location-based learning games. In general, scaffolding techniques involve different type of processes (e.g.: coaching through prompts, templates, guides or strategies) that teachers implement to support students in problem solving activities whose goals would be beyond their unassisted efforts (Wood et al., 1976). Particularly, this paper focuses on providing a strategy that could scaffold teachers in the design process of their own location-based learning games.

With the aim of facilitating teachers in the design of location-based learning games, a metaphor based on puzzle boards has been proposed (Melero et al., 2013). The metaphor simplifies a model for designing computing-supported puzzle-based games (Melero & Hernández-Leo, accepted). In this context, metaphors have been widely used as well-known concepts that facilitate reasoning about design in unfamiliar contexts (Lakoff, 1993). Besides, the use of puzzle game boards seem to offer a strategy to feasibly involve participants as game designers (Huang et al., 2007). Also, the structural design of location-based games is often inspired by board games (Nicklas, 2001; Schlieder et al., 2006). However, there are not research evidences on involving teachers in the design of location-based learning games considering puzzle game boards as a design strategy.

The originality of this paper relies on considering elements of traditional puzzle boards as a design technique to create location-based games. The remainder of the paper is structured as follows. Section 2 presents an overview of the proposed approach to design location-based games. Section 3 describes the research methodology to evaluate the puzzle board metaphor. Section 4 describes the workshop in which the teachers used the proposed metaphor to design their own location-based games. The main findings obtained from the analysis of the teachers' opinions and designs are reported in Section 5. Then, Section 6 is devoted to a discussion of the findings presented in this paper. Finally, Section 7 concludes with the main highlights obtained from the results and future research lines.

2 THE PUZZLE BOARD METAPHOR

A puzzle board metaphor has been proposed (Melero et al., 2013) as a design technique to facilitate teachers the creation of location-based games. This metaphor considers a conceptual model for creating computer-supported puzzle-based games (Melero and Hernández-Leo, accepted). An exploratory user study involving teachers from secondary and higher education were also described in (Melero and Hernández-Leo, accepted). Some of the findings revealed the need of providing a strategy to support teachers the creation of devoted environments.

Then, the aim of the proposed metaphor is to facilitate teachers the design of location-based learning games that are mainly characterised by containing routes of geolocated questions. As described in (Bontchev and Vassileva, 2010), these games consist in presenting quizzes in map where knowledge from course material is taught in a safe navigation.

In order to design location-based games of geolocated questions, the puzzle board metaphor considers the following elements (see Figure 1):

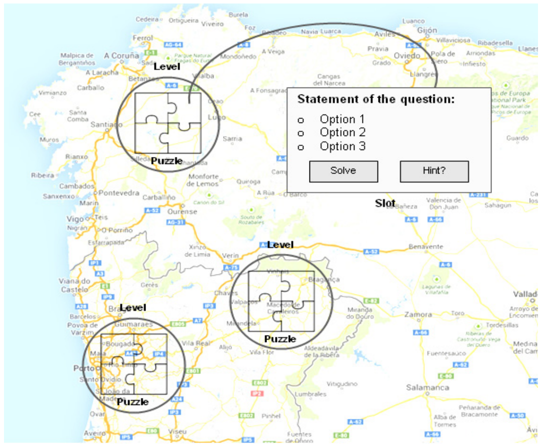

Figure 1: Representation of the puzzle board metaphor.

- The "board" is the physical space where the questions are located.
- The "slots" are the different questions, while the "pieces" are the options associated to a question. Just one "piece" can fit in a concrete "slot", meaning that there is only a correct option for each question.
- A "board" with a set of "slots" and the associated "pieces" forms the "puzzle".
- Several "puzzles" can be defined in a location-based learning game. Each puzzle has to be associated to a "level". A designer can define as different "levels" as he/she wants.
- Several "scoring" mechanisms can be defined to reflect the students' performance: a) correct answers add points to the overall player's score, b) incorrect answers subtract points the overall player's score, and c) consulting hints subtract points the overall player's score.
- Scoring can have associated a "feedback" to specific range of points in order to describe to the students their performance.

- An extra "bonus" of points can be also designed whether all the questions for a given level have been correctly answered. The extra bonus is a reward to engage and encourage students to correctly complete the different puzzles of the whole learning activity.
- Finally, "hints" can be provided in order to avoid frustrations and advance forward the location-based learning game.

3 METHODOLOGY

A design-based research (Barab and Squire, 2004) methodology has been followed to evaluate the puzzle board metaphor. Overall, this research methodology involves a continuous cycle of design, enactment, analysis, and redesign. The cycle of this research methodology involves revisions to test and refine a proposed innovative learning approach. This iterative process permits not only to validate the findings of the analysis phase, but also to reflect on how these findings alter the outcomes of the other phases (Barab and Squire, 2004).

A first iteration involved four experiments with 11 secondary education teachers that became designers of their own location-based games. The first iteration has reported the feasibility of applying the proposed approach in real learning contexts (Melero et al., 2013; Melero and Hernández-Leo, accepted). Besides, the resulted designs of the location-based learning games were implemented in "QuesTInSitu: The Game", a mobile aplication compliant with the conceptual model presented in (Melero and Hernández-Leo, accepted). In concrete, the four experiments consisted of: a) an extracurricular activity with the purpose of discovering and learning about the city where the school is placed; b) an activity associated to formatively assess their students in the art history of a city; c) an activity also with the aim of enquiring about the heritage and the city where the school is located; and d) an activity to practise the concepts associated to different pictures of a museum of contemporary art. Results showed that the different teachers were able to design their own activities, but some issues were detected: 1) a need of devoting more time in the explanation and provision of more examples in relation to the puzzle board metaphor; and 2) a reformulation in the definition of the "level" element, indicating that it may typically refer to specific physical zones or geographical areas (not only difficulty).

Thus, this paper presents a second iteration of the research methodology to gain more insights about the use of the puzzle board metaphor. To this end, a workshop session was conducted involving 20 primary and secondary education teachers in a game design task. The aim was to evaluate some changes taking into account the aforementioned considerations. The evaluation was focused on analysing the acceptance of the proposed puzzle board metaphor by the teachers, and the feasibility of using this approach to create location-based games for different educational purposes and education levels (not only secondary education, as in the first iteration).

4 GAME DESIGN PROCESS

A 4-hour workshop was carried out to evaluate the puzzle board metaphor with different teachers. Upon an open call for participation via the network for educational telematics of Catalonia (http://www.xtec.cat), 20 primary and secondary education teachers from different schools and not familiar with designing location-based games participated in the workshop. The session was divided as follows:

- Introduction (30 min). First, we introduced the context of the workshop focused on designing location-based games. Then, we present the proposed metaphor and a description of the different elements involved in the metaphor. Several examples of using the metaphor in real learning contexts (e.g. Melero et al., 2013) were also described in order to facilitate the teachers' comprehension of the proposed approach.
- 1st Questionnaire (15 min). The teachers were asked to fill a questionnaire concerning the different aspects presented before. In concrete, we asked them to: a) give an opinion about the perceived benefits of using the puzzle board metaphor; b) rate the importance of the elements involved in the metaphor, and the difficulties understanding these elements; and c) highlight the aspects that (positively or negatively) caught their attention.
- Game design task (60 min). The teachers were engaged in designing a location-based game meaningful to their particular teaching practices. In this sense, we encouraged teachers to think about an activity relevant to their teaching practices and provided the teachers with a set of templates (see Figure 2), conforming the proposed puzzle board metaphor. These templates aim to facilitate the design of the structure and content of their location-based

learning games.

LEVEL o ZONE *You can use as many 'level'/'zone' tables as you want*		
Level/Zone Name *Short name identifying the level/zone*		
Level/Zone Introduction *Text that either describes the level's (zone's) objectives or contextualizes the group of slots (questions)*		
Bonus *Extra points obtained when correctly answering all the group of slots (questions) for the particular level*		
Level Feedback *Message that appears in relation with the obtained points once the level has been completed. Several intervals of points have to be defined, as well as their associated textual message (feedback).*	points	
	points	
	points	
	points	

TITLE OF THE GAMIFIED ACTIVITY *Name to identify the gamified activity design*		
Description *General description about the game design (purpose of the game, learning objectives, etc.)*		
General Feedback *Message that appears at the end of the game when all the levels have been completed. Several intervals of points have to be defined, as well as their associated textual message (feedback).*	points	
	points	
	points	
	points	

SLOT *A slot is an empty space in a concrete point of a map where students have to go to solve a learning activity* *You can use as many "slot" tables as you want*					
Localization *Location-based point where the slot is placed*					
Slot Content *Statement describing the learning activity (e.g. question) that the students have to solve*					
Puzzle pieces *Possible options to solve the learning activity. You can add as many puzzle pieces as you want.*					
Piece Content *Text identifying the piece (e.g. possible answer)*		**Correct?** *Indicates whether the piece is correct or not*	Yes/No	**Punctuation** *Amount of added (subtracted) points depending on whether the piece is correct (incorrect)*	
Piece Content *Text identifying the piece (e.g. possible answer)*		**Correct?** *Indicates whether the piece is correct or not*	Yes/No	**Punctuation** *Amount of added (subtracted) points depending on whether the piece is correct (incorrect)*	
Piece Content *Text identifying the piece (e.g. possible answer)*		**Correct?** *Indicates whether the piece is correct or not*	Yes/No	**Punctuation** *Amount of added (subtracted) points depending on whether the piece is correct (incorrect)*	
Hint *Information to help solve the learning activity*					
				Hint points *Amount of subtracted points when consulting the hint*	

Figure 2: Templates for game designing.

- 2nd Questionnaire (15 min). After finishing the game design task, each teacher filled out a second questionnaire about the following items: a) whether the use of the templates constrain the design of the game or not; b) the understanding of the different elements of the templates; and c) the steps followed to design the location-based learning game.
- Test a demo game (45 min). The teachers, using their own smartphones, were able to test a mobile application demo using "QuesTInSitu: The Game" (see Figure 3). The demo contained 2 levels, and 3 multiple-choice questions per level about different locations near the place of the workshop.
- Discussion group (45 min). Finally, a discussion group with the teachers was carried out to share the main impressions about the proposed metaphor and the templates.

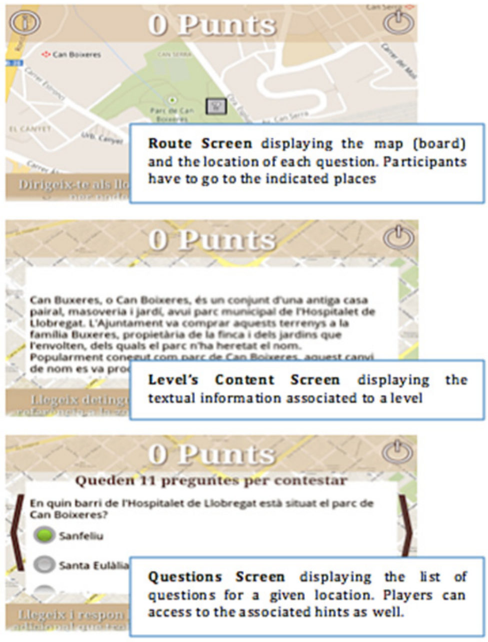

Figure 3: Some screenshots of the mobile application.

5 EVALUATION

A mixed method has been followed (Cairns and Cox, 2008) including several data sources (see Table 1) to evaluate different aspects of the proposed metaphor and the teachers' game designs. The obtained qualitative and quantitative gathered data have been contrasted and triangulated (Guba, 1981). Quantitative data, obtained from the ratings given by the teachers in the questionnaires, provide insights into teachers' acceptance about the metaphor. This obtained information will be supported or rejected by the qualitative data (Guba, 1981).

Table 1: Data gathering techniques.

Data source	Type of data	Label
First Questionnaire	Quantitative ratings and qualitative opinions by the different participants	[1st-Quest-X] Where X is the number of the participant, from 1 to 20.
Second Questionnaire	Quantitative ratings and qualitative opinions by the different participants	[2nd-Quest-Y] Where Y is the number of the participant, from 1 to 13.
Game Designs	Paper-based templates that capture the game designs	[Design-Y] Where Y is the number assigned to a design, from 1 to 11.
Observations	Record of direct observations taken during the discussion group	[Observation]

5.1 Resulted Designs

The teachers were provided with a set of templates (Figure 2) intended to allow them to design a location-based learning game formed by 2 levels and 6 questions. 7 teachers did not get involved in the game design tasks. Some of them left the room because of personal matters, and others because they expected to use an authoring tool to perform the task: "*I think it would be more interesting to use the application*" [1st-Quest -15], "*Disappointed to not could use the authoring tool*" [1st-Quest -19].

11 designs resulted from this task. 9 participants individually designed their own location-based game, while 4 worked in pairs. 3 of these games were designed for primary education [Design-2-6-7], 6 for secondary education [Design-1-3-5-8-10-11], and 2 designs did not specify the educational level [Design-4-9]. Besides, these m-learning activities were designed for different subject matters: natural science [Design-1-7], multidisciplinary activity (physical education, technology, etc.) [Design-2-3-4-9], arts [Design-5-11], literature [Design-6], technology [Design-8], and social science [Design-10].

The purpose of each design was: an activity about Olot's volcanos [Design-1]; a walking tour in Barcelona to discover different monuments [Design-2]; an activity for discovering the city of El Prat [Design-3]; a gymkhana in Ripoll's river [Design-4]; an activity in the school yard about several well-known design objects [Design-5]; a learning route about the streets of Sabadell named with popular poets names [Design-6]; a situated activity in the Zoo of Barcelona about wild animals [Design-7]; a learning activity about structures, types, and functionalities, history of different buildings and/or materials [Design-8]; an activity about the recognition of certain landscape features near the high school [Design-9]; a route for different economic institutions [Design-10]; an activity about modernist buildings in Barcelona [Design-11].

Teachers followed different approaches to design the content of the different levels. In concrete, the information of the levels was designed as a description of the geographical zone in which the questions are located [Design-1-2-7], as a textual information about the content of the questions [Design-5-8], or as instructions about the dynamics of the game for the particular level [Design-4-9-11]. The rest of participants [Design-3-6-10] did not fill out the information associated to levels' content.

Paying attention to the hints, 9 out of the 11 designs included hints as additional information about the statement of the questions [Design-1-3-4-5-6-7-8-9-11]. Only 1 participant used the hints' content to indicate physical places to find useful information [Design-2].

About the design of scoring mechanisms two approaches were followed: one more oriented to traditional tests (e.g. 1 point correct answers, -0.3 points incorrect answers) [Design-3-11], and other more oriented to games (e.g. 100 or 50 points correct answers, 50 or 10 points incorrect answers) [Design-1-2-4-5-6-7-8-9-10]. Besides, different bonus strategies were followed: adding the same amount of points as correct answers [Design-3-4-5-7-11], adding higher amount of points than correct answers [Design-8-10], and adding lower amount of points than correct answers [Design-1-5-9]. Furthermore, considering the design of points when accessing the hints, some participants chose to subtract: the same points as incorrect answers [Design-1-5], higher points than incorrect answers [Design-3-7], and lower points than incorrect answers [Design-2-4-8-9-10-11].

5.2 Results on the Proposed Metaphor

In general, the teachers had no problems understanding the different elements involved in the proposed metaphor. Specifically, all the teachers quite or totally agreed that they did not have problems understanding the role of "slots", "bonus points", "hints", and "feedback" associated to the completeness of a level and the whole game. Also, 19 out of the 20 teachers quite or totally agreed that they understood the meaning of a "level" and a "puzzle piece". However, one of the teachers said, "*I think it is difficult to implement this approach in Primary Education. I should have played the game before trying to do my own design to know how to apply this approach in my teaching practices*" [1st-Quest-14]. But, as other of the teachers indicated "*I think this approach could be perfectly implemented in primary education. Besides, it is a good approach to interpret maps and put in practice orientation skills*" [Observation].

Paying attention to the definitions of each element involved in the metaphor the results were as follows. 14 out of the 20 quite or totally agreed on the definition of allowing students to solve each question as many times as needed. But, after the game design task, some teachers pointed out that the number of trials to solve a question should have a maximun attempt limit: "*The questions should not be answered indefinitely. Otherwise, the students could do trial and error*" [1st-Quest-3-4], "*I would* *set up a maximum number of attempts*" [1st-Quest-13], "*if students have a limit amount of attempts to solve the questions, I think they would pay more attention*" [Observation]. However, each element involved in the metaphor should not be seen as a standalone item as agreed in the discussion group: "*in order to make a right use of attempts when answering the different questions (to avoid trial and error), the scoring should be designed accordingly*" [Observation]. Besides, all the teachers totally agreed that the hints allow guiding the students to find the correct answers. However, two thirds of the teachers (15/ 20) indicated that hints should be designed in those cases that were relevant. Otherwise, designing hints could become a tough task: "*we did not design hints to motivate more the exploration*" [Observation], "*I have problems to define hints that were not obvious*" [Observation]. 17 out of the 20 teachers quite or totally agreed that bonus points are a good mechanism to motivate students. Also, almost all the teachers (19/20) quite or totally agreed on the importance of providing feedback and adapted scores depending on the number of attempts when solving questions. Furthermore, 18 out of the 20 teachers quite or totally agreed that the points and feedbacks are good approaches to reflect the correct and incorrect students' actions. Some comments were: "*Feedback is indispensable when learning*" [1st-Quest-17]. However, some difficulties arosed: "*I found difficult to design the intervals for the scoring mechanisms*" [2nd-Quest-13], "*I think higher points, similar to games (such as tetris), would engage more the students in the learning activity task*" [Observation], "*I had to be very careful with the different amount of points to design a meaningful activity*" [Observation], and "*I was not sure about the amount of points to define as bonus*" [Observation]. These results indicate that despite the elements involved in the metaphor are understandable, in some cases (e.g. desining scores), it is necessary to provide teachers with recommendations to their concrete requirements.

5.3 Results on the Use of Templates

Once the teachers finished the game design task, they filled out a questionnaire intended to gather major impressions about the metaphor and use of the templates in the design task. Concerning the question "Will you find useful the metaphor to create your own location-based game?", all the 13 teachers agreed that they would use the proposed approach. Some comments were: "*This approach could be implemented in different subject topics of mine*" [2nd-Quest-9], and "*I would definitely use this approach to design punctual activities such as field trips*" [2nd-Quest-3]. The teachers also highlighted several educational benefits: puzzle board metaphor was considered a motivating approach [2nd-Quest-2-3-13] that could encourage students to outperforming themselves [2nd-Quest-4], promote learning in groups [2nd-Quest-5-7-8-12], and engage students to become more active [2nd-Quest-5-10].

When asking the teachers about the use of paper-based templates, all the teachers considered the templates a useful approach to structure the design of their location-based games. Some comments were: "*the templates help to structure the information*" [2nd-Quest-7], "*[...] to structure the whole game*" [2nd-Quest-3], and "*I understood all the elements*" [2nd-Quest-11]. Also, most of the teachers quite or totally agreed on the user-friendliness of the templates for designing the levels (9/13), slots (9/13), puzzle pieces (10/13), scoring (10/13), hints (9/13), and feedbacks (9/13).

Finally, we asked the teachers to order a list of actions according to their process when designing the location-based game: a) fill the information according to the both game's title and description; b) indicate the level's (zone's) name and description; c) define the level's scoring and feedback; d) specify the slot's description; e) define the hint associated to a slot; f) define the overall scoring and feedback of the game; g) define the bonus associated to a level; h) indicate the localization of the slots; i) define the points associated to the slot's answers; and j) define the points associated to the hints. In this line, all the participants started defining the game's name and its description, followed by the level's name and its description as well. But after this, participants followed different paths for designing their games. For instance, some of them continued their design process by defining the slot's description [2nd-Quest-2-5-7-8-13] and others by indicating the localization of the slots [2nd-Quest-3-10-11-12].

6 DISCUSSION

Over the past years, some research efforts have been done towards supporting teachers in the creation of game-based learning environments. However, the implementation of this type of environments has not been as broadly adopted as one could has expected. Most of tools have reported problems, such as, hard to adapt to specific teaching practices, requiring too many resources and too much time for development.

Thus, focusing on location-based games, it seems relevant to provide teachers with approaches that facilitate the design of this type of m-learning activities to their specific educational situations.

We believe that proposing a metaphor could be relevant to facilitate and guide teachers in the design of their own location-based games. The reason of using a metaphor can be significant to present a familiar context to the teachers in order to facilitate the comprehension of the game design task. Using puzzles boards becomes relevant in this context because these are well-known games used in educational context. Besides, board games in general has been already considered to be mapped as location-based games. Then, the proposed metaphor could be a potential approach to scaffold teachers in the design of their own location-based games.

The puzzle board metaphor has been proved a suitable approach to design location-based games. Previous experiments, despite of some misunderstandings, have reported the feasibility of designing and enacting location-based learning games for secondary education. Teachers perceived the proposed approach relevant to their teaching practices. Besides, the enactment with secondary education students revealed that the proposed approach promoted students being more active when solving the designed questions. Specifically, students tried to avoid losing points by paying more attention to elements of the physical place, asking people and searching the Internet. Further research was needed to analyse a second iteration of the metaphor in different educational levels. This second iteration, presented in this paper, has reported that elements involved in the puzzle board metaphor were properly understood. Different location-based game designs for primary and secondary education resulted from the task. Besides, participants were able to design their location-based games according to their specific requirements.

Furthermore, paper-based templates have been proved to be a good approach to put into real practice the proposed metaphor. The templates has been useful to structure the content of the designed location-based games. Also, this paper-based approach gives insights towards the design and the development of an authoring tool compliant with the puzzle board metaphor. In this context, the authoring tool has to be flexible enough to allow teachers to follow different paths when desining their own location-based games.

When designing location-based learning games it is important to consider the effects of design decisions in concrete elements will have on the rest; the different elements involved when designing this type of activities should not be treated in isolation. For instance, the design of the scoring mechanisms could influence on answering questions or accessing to the hints. Besides, results have shown that it would be advisable to provide recomandations to the teachers about scoring mechanisms. Different strategies can be followed to design diverse types of scoring mechanisms: adding/subtracting higher amount of points (e.g. 100 points correct answers, -50 points incorrect answers) versus following a more traditional assessment approach (e.g. 1 point correct answers, -0.3 points incorrect answers). Thus, it seems relevant to integrate some kind of guidance for teachers that recommends which scoring strategy follow considering his/her educational needs.

7 CONCLUSIONS

This paper has described a strategy based on a puzzle board metaphor to facilitate teachers the design of their own location-based learning games. Particularly, in the frame of a design-based research methodology, the paper presents a second iteration in the formulation of the metaphor and the associated design process. The evaluation of the iterated approach focused on analysing the changes performed in the definition of the "level" element and the dynamic of the game design task. Results have shown that teachers have properly understood the proposed approach and highlighted many educational benefits. The great majority of teachers agreed with the definitions of the different elements involved in the proposed metaphor. Besides, participants become aware of the importance of not considering the elements of the metaphor as isolated items. Designing appropriate scores could influence in avoiding trial and error.

The puzzle board metaphor has been proved also to be a feasible approach to define location-based games for different contexts and educational purposes. Besides, the use of paper-based templates have been positively valued for structuring the content of the activities, as well as for flexibly designing these m-learning activities.

As a whole, teachers positively adopted the proposed approach and sought for an authoring tool. In this line, results obtained in the evaluation have provided insights to further work in the implementation of an authoring tool that allows the creation of location-based games. Results obtained in the design process indicate that teachers follow different paths when designing their own location-based learning game. This suggests that the authoring tool should not enforce a guided process. Instead, the tool should provide enough freedom to allow the teachers to follow their own desired path to create their location-based games. Besides, one of the findings is about the dificulties when designing adapted scores because teachers are not sure which would be the better approach to follow. Implementing recommendations in an authoring tool to facilitate this task is one aspect that requires further research.

Finally, a follow-up experiment with teachers who attended the workshop would be relevant to evaluate more deeply the usefulness of the proposed approach. Previous real experiments have proved the feasibility of implementing location-based learning games for secondary education using the paper-based templates. However, this study has presented designs in other educational levels and subject topics that could be worthwhile to implement in order to evaluate the impact of using the proposed approach.

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Adaptive M-learning Application for Driving Licencess Candidates Based on UCD for M-learning Framework

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Keywords: M-learning Application, UCD for M-learning Framework, Driving Licences.

Abstract: This paper reveals the adaptive mobile learning application that we have designed and developed for driving school in Helsinki, Finland. The application development is considered as a case study for User Centred Design (UCD) framework specific for mobile learning. The overall aim of this case study is to assess the UCD framework. The main goal of the proposed UCD method is to ensure that the stakeholders, especially students, recognize the mobile learning application as a learning medium that meets their essential educational demands. The UCD for m-learning application development framework mandates users' involvement in all stages of product concept development phases. The result of applying UCD for m-learning application framework is an adaptive mobile learning application specific for driving license candidates. This application helps students to study, learn and asses the compulsory driving school theory lessons on their smart devices. Additionally, the application provides mandatory self-evaluation report to instructors after each practical driving session. The application prototype evaluation results indicate that test users are able to carry out the predefined tasks independently. Test users find the application useful and fun to use.

1 INTRODUCTION

Smartphone's penetration among youth is increasing with a fast pace (Maged et al., 2011) and (Mostakhdemin-Hosseini et al., 2006). Youth spend more time with smartphone applications than their PC counterparts. The penetration and the excessive usage is a result of advancement in wireless technologies and smartphones. The numbers of mobile applications such as game, social networking, entertainment, personal and professional are increasing rapidly. These applications are constantly competing for users' time and attention (Dirin et al., 2013). Mobile learning application development however, requires extensive consideration as the application deals with learning and learners alike. M-learning application must meet students' essential educational requirements and also encourage students to engage with the application on their smartphones (Keinonen et al., 2003); (Seong et al., 2006); (Zhang and Adipat, 2005) and (Mostakhdemin-hosseini, 2009). Moreover, the m-learning application should follow the pedagogical principles and requirments (Kukulska-Hulme, 2007); (Trinder et al., 2007), (Corlett and Sharples, 2004) and (Mostakhdemin-Hosseini, 2008).

The User Cenetred Design (UCD) for m-learning application (Dirin and Nieminen, 2013) is proven successful framework to design and develop a usable mobile learning application. This framework puts intended users of the target application at the center of its design and development.

The driving licences application development required extensive functional and non-functional considerations. This application enables the driving school candidates to complete the compulsary theory lessons on their smartphones. The application functionality implementation associated with two distinct challenges, 1. the content preperations and 2. the user interface design. The content of driving licenses theory lessons must follow the standard mandates and regulations defined by goverment organization. Additionally, the content of the theory lessons must be easy to comprehend and simple to use and soft navigate. As a result multi-formated content e.g. audio, video and animations are considered the best approach.

The application follows the user's learning progress by conducting evaluation test after each theory lesson. Moreover, the application provides a self-evaluation form after each practical driving session. The application then forwards the completed self-evaluation form to proper instructors at the driving school. Based on submitted self-evaluation form report the application also notifies instructors if imidiate attention is required.

The application also recommends the follow-up learning lessons based on user's knowledge and reading history. We refer to this functionality as a part of the application adaptivity. There have already been many initiatives (Vainio and Ahnonen, 2003) and (Jäppinen et al., 2004) to provide adaptive mobile learning applications to improving the usability and learning processes.

In our project we considered the content adaptivity and application usability as major factors for easing the learning process and knowledge creations.

The non-fucntional requirements of the proposed driving licence application are as important as the functional requirments. The application should be reliable, the user should also feel secure to use and most of all be usable. In this paper however, we focuse mainly to the functional requirements and the development steps that are based on the UCD framework for mobile learning application development.

2 APPLIED METHOD

2.1 User-centred Design

The term User Centred design originated by Don Norman during 1980s after publication of book entitled: *User-Centred System Design, New Perspective on Human-Computer Interaction* (Norman and Proper, 1986) User-Centred Design and development of interactive systems and devices has an increasing importance in product development organizations (Nieminen, 2004). In addition, UCD is the most common method for developing a smart product. Gould (Gould and Lewis, 1985) and (Gould et al., 1997) argued that in a usable system, we need to involve users' continually, and based on user's feedback, modify the design. The user-centered design (UCD) cuts both costs (Bosert, 1991) and (Gulliksen et al., 2003) and improves usability, since it continually focuses on the essential needs of the customer as early as possible. The user's requirements are the focus in all stages of the product development cycle. Human-centred design (ISO 9241-210, 2010) processes for interactive system (Sharp and Rogers, 2006) and (ISO 13407 Model, 1999) defines three different design solutions for UCD as: I. Cooperative design; designers and users involved in all stages II. Participatory design; users' occasionally participate in the design process, III. Contextual design; design based on the actual context. The UCD phases are as follow, 1. Get to know the users 2. Analyze user tasks and goals 3. Establish usability requirements 4. Prototype and then design concept 5. Usability test of the concept and 6. Repeat the stages as there are more features/ services.

2.2 User Centred Design (UCD) for M-learning Application Framework

This case study is based on the User Centered Design (UCD) method specific for m-learning application development framework (Dirin and Nieminen, 2014). The following diagram reveals the UCD for m-learning application development phases.

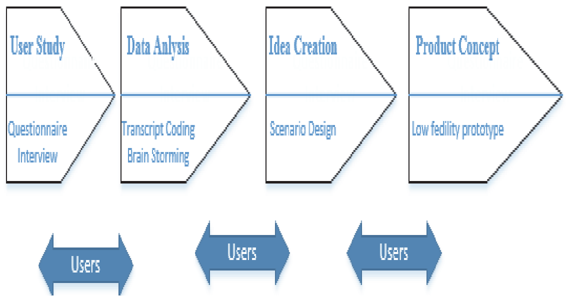

Figure 1: User-centered design process for m-learning application development.

User Study Phase (Understanding the User). The user study phase is the essence of the UCD for mobile learning application development. At this phase target stakeholders are identified and their real needs are investigated by applying various user study methods such as a diary, interview etc. The user study method such as a diary helps the designers to learn about the user and their environment in which they often interact. *Standard* UCD methodology recommends 3-10 target users' involvement at various user studies stage *(Usability Research Group, 2002).*

Data Analysis Phase (Identifying the Interactions). The gathered data in the previous phase is row data, which requires processing for identifying the users' real needs. There are various data analysis methods such as transcript coding, user task and environment analysis can help to classify and categories the user requirements. Affinity diagrams are the recommended method for categorizing and prioritizing the requirements.

Idea Creation Phase (Producing Design Solution). At this phase we need to confirm those categorized and prioritized requirements with the potential test users. This confirmation ensures that designers understood the users' needs properly. Additionally, this is yet another opportunity for target users to impact to the proposed requirements. We present the categorized requirements as scenarios. Scenarios are the best approach that we promote in the mobile learning application concept design method. As the scenario speaks user's language and often avoids technical terms and complexities.

Product Concept (Evaluating the Designs). In this phase the application concept is modified based on the gathered data in the previous phase. The application concept is now ready to be implemented as a non-functional prototype. The prototype consists of the potential user interface components and the navigations of various screens. In the last stage of users' involvement in the design process, we conduct usability evaluation test for the proposed application prototype. The target application design refinement is based on the usability test results

The UCD for mobile learning application is an iterative design method. In this method, the concept development mandates the users' involvement at all phases of the mobile learning application development which minimizes the application failure and maximizes the penetration of the application among the target users.

3 CASE STUDY “M-LEARNING APPLICATION FOR DRIVING LICENCES”

The mobile learning application for driving school was designed and developed during 2012 at HAAGAHELIA University of Applied Sciences, Helsinki, Finland.

The application is developed based on UCD for m-learning application development framework. The first phase of the framework mandates the direct involvement of the potential application users for understanding users' needs and tasks. In this case study we conducted, our user studies with students and instructors at Haaga driving school in Helsinki. We applied different user study methods such as diary, web questionnaire and semi-structured interview. We asked seven (n=7) driving license candidates to take part in our user study sessions. The age distribution of the users is from 18 to 25 years old. In addition, 5 instructors were also involved as potential users of the mobile learning application and admin tool concept design. The age distribution of the instructors is from 20-55. The user studies are carried out in Helsinki metropolitan area. We utilized the web questionnaire and diary to learn about our users' daily activities, types of smart gadget they currently use, most frequently used mobile application or most often downloaded, and the level of computer knowledge. After having the basic knowledge on our users through diary and web, we scheduled an individual semi-structured interview. The interview sessions often took 20-30 minutes and all the discussions were recorded with the user's consent. After the user study phase, we applied various data analysis methods such as transcript coding and affinity diagram to explore the users' real needs and requirements for the target application. We categorized a list of requirements with the priority level. Based on the list of requirements, we wrote scenarios in which the requirements were presented as the potential function of the target application. We then came up with three different scenarios which the first scenario reflects implementation of the application based on users' requirements in future technology where technology far more advanced than now. The second scenario reflects the current technology and the third scenario reflect the existing resource to implement the prototypes. In the following figure a sample scenario of the target application is presented

> A bell rings in Tomi's mind, **after submitting** the self-evaluation feedback. Considering the driving session was not-so-positive, at least he could compensate with good scores in **theoretical knowledge**. Therefore he decides to take a **theory test**, using the same **web application**, while waiting for the bus to take him home. A specifically designed ***function is available***, in the main website menu. …

Figure 2: Scenario for theory test of driving m-learning application.

The scenarios are then shared with six (n=6) users. Three (n=3) users were selected among those users who have participated already in the first phases of the user studies and the rest were new users. The admin tool scenario for the instructors was also shared with three driving school instructors.

Test users were asked to read the scenarios one by one and then the user study expert conducted an interview about the scenario. Similarly, with user's consent all the discussions were recorded for further analysis. The collected feedback from all users was analyzed, which helped us to recognize more valuable functional and non-functional requirements.

This proceeded with the design of a paper- based prototype of the target application. The paper-based prototype then was consulted again with the test users for final revisions of the concept. We conducted a usability evaluation test for the proposed prototype. The usability test was carried out at the media-lab in Haaga-Helia University of Applied Science. Through usability evaluation we assessed the functionality and the user interface of the target mobile learning application.

Finally m-learning application for driving school is designed and proposed for implementation. In all processes of the application design and development the user experience factors such entertainment; delightfulness and adjustability of the learning application were in the center of the design theme (Dirin and Nieminen, 2013)

3.1 Prototype Implementation

Selecting the right smartphones' platform for implementing the prototype was the first challenges that we encountered. There are many smartphones in the market and each of which has a unique development and usability requirements. We came to the conclusion that we develop a cross platform application as it is not possible to anticipate the potential users' smart devices. We select HTML5 and JQuery as the most appropriate technology for developing the application for all the latest smartphones (Dirin et al., 2013). HTML5 is considered as cross platform that provides a consistent UI across the latest smart devices. We however ensured that the selected HTML5 API's support the latest smartphones. For the server and backend implementation, we have utilized Microsoft Technologies such as MS MVC4, MS SQL Server 2012 and MS Server management Studio.

With the help of this application the driving license candidates are able to study, complete and pass the compulsory driving school theory test. Additionally, with the help of this application, the instructors at the driving school are able to receive instance reports about students' practical driving performance. The report consist of students' self-evaluations on the driving experience besides other data such as GPS data, durations of the driving practice and the route that the students has taken during the practicing driving session. The following diagram presents the application self-evaluation concept.

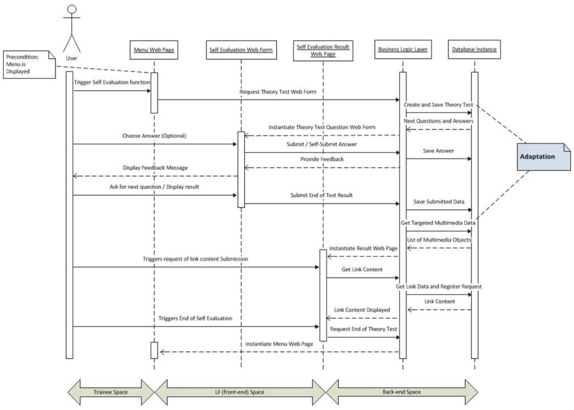

Figure 3: Sequence diagram of m-learning driving application, Self-evaluation concept.

The actual content of the learning materials are provided from the server by application query. Students are able to make a query for a particular content or a topic at their convenience. The application assesses the users' knowledge based on the previous learning activities. The content is then provided to students in three different circumstances. I. User may select an active topic from table of content in the theory section of the application II. The application may propose content to user after random theory test. III. The application may propose content immediately after reporting the self-assessment form to instructors.

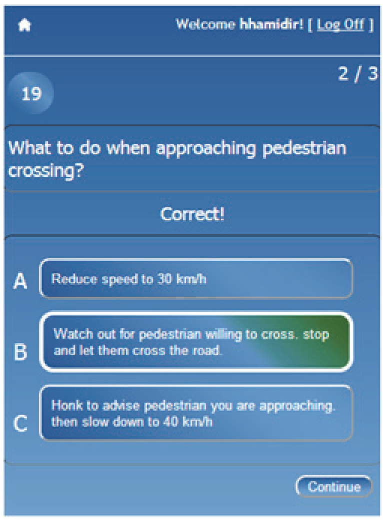

Figure 4: Self-evaluation screen shot.

The application UI is consistent, interactive and supports touch and non-touch smart devices.

The application provides the content to the user in various formats which depends on the context of the query. Nonetheless, the application supports video, audio, animation and text-based formats.

Each theory sessions consist of an evaluation test. Passing the evaluation test is prerequisite for starting the next topic. The new topics are dimmed and the user is not able to select. In case the number of failed answers exceed to certain percentage. The application discards the lesson and recommends user to re-take the lesson. The users also can suspend the reading or the self-evaluation test at any time. The application however keeps track of the user's readings and self-evaluation activities. As a result users may continue the reading tasks or self-evaluation test in their convenient time.

After each practical driving session, students must submit a report to the instructors. The content of the report form and the questions are customized by the driving school instructors. The content of the report form personalized by instructors based on students' theory achievements and previous driving experience reports. The application reacst instantly on the reported form after driving session. If severe errors occur during driving sessions the application warn the student about the seriousness and prompt a proper content for further studies.

The following screen shot shows the driving session self-evaluations application form. The application UI is customized both for touch and n-touch devices.

Figure 5: Self-evaluation form after the driving session.

The administrative tool is the most important part of the driving licence application. With the help of this tool the instructors define the application content, self-evaluation test content and criteria for passing the theory lessons. Additionally, the administrative tool provides a unique report to the instructors about the students' performance on the theory part and in the practical driving sessions. The administrative tool is compatible with mobile and PCs, we have considered both pc and mobile versions as the instructors often on the move or in office. Similar to the self-evaluation question UI, we have used colour coding for instructions to check the report of each student instantly. The instructors are able to print out the students details learning history and driving session progress summary reports. The following screen shot presents the instructors' admin tool.

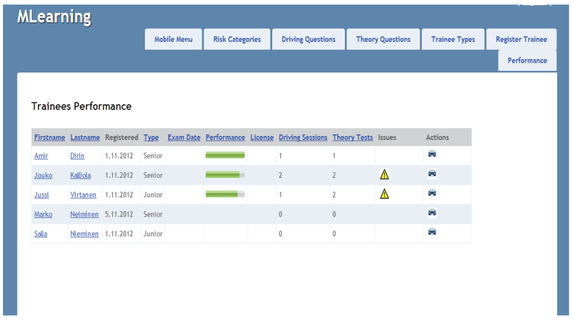

Figure 6: Admin tool's screen shot.

4 CONCLUSIONS

In this case study we utilized a User Centred Design (UCD) framework specific for m-learning application development. This case study strives to assess the UCD framework by developing the mobile learning application for driving schools and driving licenses' candidates. The UCD for m-learning application development framework ensures that the users of the application are directly involved in the application of the concept design. The framework results in an application that meets all the usability criteria. The prototype evaluation report indicates that the application is easy to use and provides the essential learning materials for driving school candidates. Users are specially satisfied that the driving theory lessons are accessible at anytime and anyplace. Additionally, the UCD framework for mobile learning application helps to develop a mobile learning application that is adaptive, interactive and easy to use. The usability reports show that these features in mobile learning application provides positive user experience for our test users. The UCD framework results in this case study and application that is dynamic. The application content and UI is customizable based on students' performance on theory lessons evaluation and practical driving session reports. Moreover, the application supports multi-formatted content. Students may select one or combinations of many formats based on the context and the content of the learning materials. The main focus in this case study is to assess the UCD application development frameworks' efficiency. The pedagogical considerations or evaluations are out of the scope of this study.

5 FUTURE WORK

This case study is designed, developed and evaluated with the help of one driving school in Helsinki. As future work, we plan to test the application in different driving schools in Helsinki and possibility in different cities. The results will help us to compare the application performance and users satisfactions more accurately.

We have not assessed the pedagogical perspective of the application. It is important to study the learning efficiency of the proposed mobile learning application. And to assess how the proposed mobile learning application helps students to learn more efficiently? And to find out whether students comprehend the mobile-learning materials as easier than the traditional approach.

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Metacognitive Support in University Lectures Provided via Mobile Devices

How to Help Students to Regulate Their Learning Process during a 90-minute Class

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Keywords: Mobile Devices, Self-regulated Learning, University Lecture, Metacognitive Support.

Abstract: Even though classical lectures at universities are criticized for lacking interactivity and treating students like passive receptors of information they are still very popular. Due to the big amount of students, interaction between teacher and students is difficult to realize. Several projects address this problem by offering technical solutions which aim at increasing the interactivity during classes or lectures – classic clicker-systems as well as solutions in which students use their own smartphones, netbooks or tablet-PCs. Based on research on self-regulated learning (SRL) processes we developed the already existing tools one step further: instead of only providing questions we designed Auditorium Mobile Classroom Service (AMCS) – a program which offers several possibilities to interact during a lecture. AMCS supports students to regulate their own learning process during the lecture. Learning questions are one core element to support them. On the basis of the results of the learning questions specific advices and hints are sent to the students' smartphones or notebooks. The features increase the interactivity between the content and students and the interaction in the lecture hall. In the present article the program AMCS is described. Furthermore we report first experiences from a field test in a university lecture.

1 INTRODUCTION

Lectures are still an important form of teaching courses at universities. They aim to expand students' knowledge through the structured presentation of expertise from a teacher. This form of teaching has been criticized for offering too little interaction between teachers and students. Learning as an active, constructive and highly individual process (Seel, 2003) is almost impossible in huge lectures. As a consequence, students experience severe difficulties – they do not manage to build adequate mental models of the taught domain.

There are several approaches to increase the interactivity in lectures. The spectrum ranges from simple voting systems to the method of peer instruction (Mazur, 1997). A large variety of systems especially useful for implementing learning questions in lectures are subsumed under the concept "audience response systems" or "clickers". Audience response systems provide feedback to the lecturer by giving the audience the possibility to participate during the class by voting on questions. By presenting questions during the class students get more involved in the lecture and the lecturer in turn gets some information about the audience's knowledge and attitudes. Almost all of these systems work as follows: the lecturer defines a question before starting the class; during the lecture the question is presented on the screen and the students are asked to answer via special technical devices (clickers) or their smartphones; all answers are aggregated and immediately pictured on the presentation-screen. The lecturer can include the answers from the audience into the lecture – provide feedback to the audience or adapt the lecture to special interests or needs. There are some studies showing that audience response systems are capable of increasing the interactivity in lectures and leading to an improvement in academic achievement (e.g. Mayer et al., 2009). A prerequisite for these positive effects seem to be that the application is accompanied with strategies that engage students in deeper processing (Brady et al., 2013). For example, Lantz and Stawiski (2014) point out that obtaining feedback after working on the questions is crucial for an improvement in learning.

We took existing systems like SMILE (Weber & Becker, 2013) as a starting point and combined first experiences with the results of the research on self-regulated learning and learning questions. On this basis we extended the concept of classical audience response systems. Our main goal is to support students during large university lectures in achieving their personal learning goals. On the basis of SRL models we developed a system to provide interactive learning questions, cognitive and metacognitive prompts to students in university lectures. With Auditorium Mobile Classroom Service (AMCS) the lecturer designs in advance of the class learning questions with feedback and messages with additional information. These messages and learning questions are delivered during the lecture in order to facilitate successful regulation of the learning process of each of the participants.

From a technical perspective we added one direction of communication – in contrast to existing systems AMCS does not only give the students the possibility to vote during the lecture, the professor gets the possibility to communicate to them during the class as well. That way the lecture is designed as an individual adaptive learning process. In the following sections the core elements of AMCS are described.

2 FEATURES OF AMCS

Models of self-regulated learning (e.g., Zimmerman, 2000) identify the requirements that must be met by students at different points in the learning process. Zimmerman (2000) assumes that the forethought phase, the performance phase and the self-reflection phase are recurrent at different levels during a learning process. The goal orientation, attribution style and individual differences in prior knowledge, for example, have an impact on the forethought phase and the planning of the learning process. Depending on these variables students may differ in preparing for university lectures. Planning and preparing for the lecture is crucial for the successful knowledge acquisition. During the performance phase the diverse information needs to be processed. This includes the use of pre-selected learning strategies and the maintenance of motivation and attention. In the self-reflection or evaluation phase, learners should reflect on their learning process and achievement and derive implications for future learning activities. Processes during the performance and the self-reflection phase are influenced by individual differences as well. Depending on the capability to concentrate, the personal goals and interests learners master the demands of these two phases differently. This results in different learning outcomes. AMCS aims at supporting students in self-regulated learning taking into account that individual differences of the students play a decisive role.

In the following section the features of AMCS are presented. All instructional interventions are delivered via mobile devices (netbooks, smart-phones, tablets) during the lecture.

2.1 Interests / Personal Goals

At the beginning of the lecture students are asked for their personal goals and interests. Why are they attending the lecture? Are they interested in the topic or focused on passing the exam? The goals must be taken into account when supporting students in regulation during the lecture. Therefore, the information collected is used as a basis for metacognitive prompts. Metacognitive prompts are instructions that are sent to the mobile devices of the students during the lecture. They contain information which helps them to regulate their personal learning process depending on their goals and interests. Besides, students shall be encouraged by this short survey at the beginning of the lecture, to be clear about their goals and interests.

2.2 Learning Questions at the Beginning, in the Middle and at the End of the Lecture

Interactive learning questions are implemented to support the learning process both on a cognitive and a metacognitive level. Located at the beginning, in the middle and at the end of the lecture they assist students in an active engagement with the content. Prerequisite for the effectiveness of learning questions is the consideration of certain design rules. Körndle, Narciss and Proske (2004) identified four dimensions, which can be systematically constructed: 1) format, 2) content, 3) cognitive operations necessary to solve the question, and 4) interactivity. Within AMCS the question format multiple-choice is available. The interactivity goes beyond already existing tools. AMCS allows designers to implement a two-step feedback algorithm defining specific feedback for any option. In contrast to other audience response systems learners receive individual feedback on their mobile devices. They can answer the learning questions twice before the correct option is displayed. Feedback contains information whether the answer is correct or not and in case of an incorrect answer hints on how to go on.

Learning questions at the beginning aim at activating prior knowledge. In addition, the requirements of the lecture are communicated through the learning questions and the attention of the students is guided to specific content. After half of the lecture, the students can use the learning questions to practice the recently learned concepts and to get feedback on their level of knowledge progress. At the end of the class learning questions again aim at practicing relevant concepts and are useful for the self-evaluation of the learning process. As learners obtain feedback on their level of knowledge they can draw conclusions for future events - concerning the regulation of attention and motivation as well as the application of learning strategies. In contrast to already existing audience response systems AMCS is accompanied with an instructional concept which contains interactive learning questions as a core element and theoretically deduced how and when to implement them in the lecture.

2.3 Metacognitive Prompts

During the lecture metacognitive prompts are sent automatically to the students. They aim at supporting the students in reaching their personal learning goals. As they address regulation processes on a more abstract level we named them “metacognitive prompts”. The prompts are delivered depending on personal goals and characteristics of the student (e.g., learning goal orientation, exam preparation or interest in the topic) and depending on how they did in the learning questions.

In advance of the lecture the professor designs messages containing helpful information and prompts for different goals (e.g., exam preparation vs. research interest) and different motivational states (no interest in the topic at all vs. really curious about the topic). At the beginning the students are asked about their goals and motivation with the help of a short questionnaire. Based on their answers they get adaptive metacognitive prompts during the lecture. An example of a metacognitive prompt, which intents to help the students to adapt their learning behaviour to their goal “passing the exam” is the following:

"On the following slide the concept X is explained. This concept is relevant for the exam. A question of how it is raised repeatedly in the oral examination is, for example: Why is it important to apply concept X when starting the process?" Students are required to select and process content, which is relevant for their personal learning goals. At the same time the personal goals can significantly differ within a group of students attending the same lecture. Thus, it results to be difficult for the lecturer to address all the different goals in one session. As a result students fail in selecting relevant information and differentiate between important and marginal content. The messages sent by AMCS containing metacognitive prompts introduce adaptive support to students in order to reach their personal learning goals.

2.4 Cognitive Prompts - Individual Adaptive Feedback during the Lecture

Learning questions at the beginning of the lecture and in the middle are not only interventional tools to support students in knowledge construction. They also deliver diagnostic information on the state of knowledge acquisition of the students. This information can be used to promote knowledge building and further develop students’ mental models.

Learning questions with several response options offer the possibility to incorporate typical misconceptions about concepts and theories. If the mental model contains misconceptions and the incorrect answer is chosen, the cognitive prompts can support students in correcting the misconception and overcome these obstacles. AMCS initiates corrective processes by sending the student a cognitive prompt at the moment the misconception is explained by the lecturer.

If a student, for example, selects an incorrect option to the first learning question at the beginning of the lecture, then he gets the following message when the lecturer is explaining slide number 13 of his presentation:

"You have made a mistake in the first learning question at the beginning. For some reason you thought that concept X is the answer to the question. What it really means is explained by Prof. Y on the current slide."

The cognitive prompt should initiate behaviour which leads to the correction of the misconception. In order to do so it names the misconception and draws the attention to the explanation of the concept by the lecturer. These messages are referred to as cognitive prompts as they directly address concrete information and have the goal to stimulate information processing of specific content. They might also initiate regulation behaviour as the consequence of a corrected misconception can be changes in learning behaviour. Thus, the main difference to metacognitive prompts is the level of intended effects: cognitive prompts aim at integrating or correcting specific content, whereas metacognitive prompts put the focus on general regulatory mechanisms such as the maintenance of attention or the understanding of demands. It is also possible to combine both types of prompts.

2.5 Providing Further Material to the Students – Scripts, Links and Additional Texts

AMCS offers the possibility to provide further materials to the students. These include links, PDFs, and slides of the presentation. The materials can be chosen adaptively to the individual goals of the students and/or to their learning behaviour. An example of a message with further material for students who are thinking about doing research or writing their thesis in the field of the lecture is as follows:

"You have indicated at the beginning of the lecture that you are interested in writing a thesis on this topic. The chair is doing research on the topic which is presented on the current slide. You can find possible research queries for a Bachelor thesis on the subject under the following link: http:// .... "

2.6 Scripted Discussion – How to Animate Students to Ask Questions Which Are Helpful for Them

The sixth feature of AMCS applies during the time slot, which is normally reserved for a discussion. Both the auditorium and the lecturer exchange ideas and questions at the end of the lecture. By sending the students messages AMCS intends to initiate this exchange and involve students who normally do not participate in this interaction. In exceptional cases, the discussion may even be staged. Pro and counter-arguments could be distributed among the audience. One example for a message with a request for a comment that aims at starting the discussion is the following: "Stand up right now and ask the following question loudly into the room: What's the practical use of this theory?" The goal of this feature is to use the time reserved for discussion and interaction between the lecturer and the students in an optimal way.

3 PILOT STUDY

The AMCS prototype was tested in a 90-minute lecture on psychology. The evaluation had mainly three goals: we wanted to figure out if (1) the tool works properly during the lecture (Does the tool deliver messages and learning questions at the correct moments etc.?). Furthermore we aimed at (2) checking if the intervention is accepted by the students (Do students appreciate the usage of mobile devices with the reported features during the lecture?). Finally we wanted to investigate (3) whether AMCS is able to produce positive effects concerning motivation, concentration and achievement. We gained data to answer these questions from log-file analyses, self-reports of the students and achievement tests.

3.1 Technical Infrastructure

AMCS is based on a service-oriented system with different client applications for students and lecturers (see Figure 1). The students' client enables them to get prompts and questions during the class. The interventions are delivered via inbound and outbound messages on their smartphones or other Internet-enabled devices (tablets, netbooks or notebooks). They interact with the service via web based application over an REST-API. This has the advantage of platform independence over all device classes.

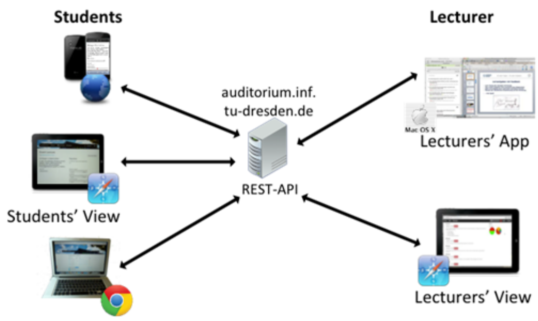

Figure 1: system architecture of AMCS.

The responses of the students are stored in a database on the Auditorium server. On this basis, learners receive messages which are sent automatically by the system. The timing of message dispatch is dependent on the actual presentation of the lecturer. Therefore it is necessary that the server communicates with the presentation device of the lecturer while the class is taken place. This synchronization with the presentation system (e.g., PowerPoint, Keynote or PDF) is done by the lecturers' app, which was implemented as native Mac OS X application as well as a desktop application for Windows. Within this application the lecturer defines in advance of the class on which presentation-slide which specific message will be sent or which questions have to be answered.

During the class the professor can use the lecturers' view of the AMCS web application to see how the students are doing. By observing the voting results and answers in real-time lecturers can adapt the pace of their presentation or address content which was not understand yet.

3.2 Method

Thirty students (10 men, 20 women, mean age: 25.8 years, SD: 5.1 years) from a German university participated in the field study. The sample size differed between 22 (all evaluation data including questionnaires and knowledge test) and 30 persons (log-files during the lecture – delivery of messages and learning questions) as some of the participants did not fill out the post-questionnaires. Within the sample smartphones (11), tablets (2), netbooks (9) and notebooks (7) were used (missing information for one participant).

The lecture was on the topic of self-regulated learning, which is regular part of the curriculum in the field of learning and instruction. Before starting with the lecture every participant was requested to answer the pre-questionnaire asking for interest in the topic and motivation to attend the lecture. Afterwards they received their personal login for the AMCS platform and the class started. At the end of the class participants answered the post-questionnaire containing several measurements about motivation, usability and a knowledge test.

3.3 Results

3.3.1 Technical Functionality

Nine persons reported that their devices work either with iOS or with OS X, 10 devices were based on windows operating systems and four on android. Seven participants did not report on which basis their devices work. The log-files from the data bank revealed that the 26 users assessed created 206 logs concerning the learning questions. In average 7.9 actions per person referring to the learning questions were documented. There were 67 entries in the database regarding the three questions at the beginning of the lecture (concerning the goals and interests of the students). As 26 users are registered it is clear that not all of the participants answered all questions. During the lecture 98 messages containing either cognitive prompts, metacognitive prompts, further information and material or suggestions for the discussion at the end were send to the mobile devices of the participants. The average of messages sent was 3.8 per participant.

The comments in the post-questionnaire revealed a number of technical problems which participants experienced during the session. One student was not able to connect and login into the system at all. Further comments addressed a mixture between languages in the user interface (2), that messages should be high lightened in some way (2), that the feedback algorithm can be improved (1), that there were technical problems with the learning questions at the end (1).

3.3.2 Acceptance

Participants were asked in the post-questionnaire if they would recommend the program and would like to work again with it. Twenty-one participants answered the questionnaire of six items. The mean value for the group is 3.76 (SD = .68) on a scale from 1 "I do not agree" to 5 "I fully agree". The item asking if they consider the functionalities useful (learning questions, messages and feedback to the lecturer) was rated 4.19 (SD = .68). The usability criteria "conformity with user expectations" (5 items; M = 5.8, SD = .93), "suitability for the task" (5 items; M = 5.3, SD = .86) and "self-description capability" (5 items; M = 4.7, SD = 1.00) were rated positively. The scale ranges from 1 "---" to 7 "+++".

The lecturer positively annotated that he could use his normal presentation (based on PowerPoint) and was able to see the results of the learning questions and questionnaires in real-time.

3.3.3 Motivation and Knowledge

Twenty-two participants answered the questionnaire on motivation, concentration and attention compared to normal lectures. Scales ranged from 1 "I do not agree" to 5 "I fully agree". Students rather agreed that their concentration (M = 3.55; SD = .79), attention (M = 3.39; SD = .72) and motivation (M = 4.09; SD = .71) was higher with AMCS. There was one item asking for an overall judgment on the lecture with AMCS compared to normal lectures. Participants of the field study rather agreed ($M = 3.14$, $SD = 1.04$) to the statement "By using mobile devices in this lecture I learned more than in normal lectures." Interests on self-regulated learning ($n = 19$; 7 items) and motivation to study ($n=21$, 3 items) before and after the lecture were assessed with questionnaires. There were no significant changes from pre to post (interest: $t(18) = -.57$, $p > .5$; motivation: $t(21) = -1.5$, $p = .15$). Both interest ($M_{pre} = 3.03$, $SD_{pre} = .68$; $M_{post} = 3.08$, $SD_{post} = .61$; scale ranging from 1 to 4) as motivation to study ($M_{pre} = 5.24$, $SD_{pre} = .59$; $M_{post} = 5.35$, $SD_{post} = .54$; scale ranging from 1 to 6) remained on a high level. Twenty-two students participated in the achievement test. Scores ranged from zero to eight points (the test has 10 items – one point for each item was given). The mean score was 3.96 ($SD = 2.40$).

4 CONCLUSIONS

Auditorium Mobile Classroom Service (AMCS) provides an opportunity to support students during university lectures. The six features aim at fostering regulation and mastering demands of self-regulating learning. The core elements of AMCS are derived from empirical studies (e.g., Kapp, Proske, Narciss, & Körndle, 2011) and theoretical considerations based on models of self-regulation (e.g. Zimmerman, 2000). The first test of the pilot is seen as a demonstration of how learning questions, cognitive and metacognitive prompts can be used in university lectures in order to support students in mastering the demands of this learning situation. Via mobile devices, university lectures are made adaptive – learning questions and individual prompts are tailored to the personal goals and learning processes of the students.

The interactivity is increased by interventions, which animate students to engage in content (learning questions) and by establishing a communication channel (via the mobile devices of the students), which allows the learning environment to interact with the students (via predefined prompts and messages by the lecturer).

The results of the pilot are of course limited and do not go beyond the examination of requirements necessary to generate learning effects. These requirements are for example technical functionalities and acceptance of the system and self-reported attention, concentration, motivation and achievement. The first evaluation suggests that the minimum requirements are met. The intervention was not perceived as distraction nor judged as difficult to use during the lecture. The usability of the system was rated as good and beside some technical problems students would recommend AMCS and further use it. First critical arguments could be refuted: the distraction of the usage of mobile devices during the lecture does not seem to constrain learning and the need of extensive computer literacy is not a requirement to use AMCS. Nevertheless the data is not sufficient. In future studies we want to test the system and its components in large lectures and empirically evaluate the effects of the single features.

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Stamp-On: A Mobile Game for Museum Visitors

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Keywords: Mobile Guidance, iPad Mini, Learning Game, Tangible, Explanatory Contents.

Abstract: This paper proposes Stamp-On, a mobile guidance aid for museum visitors. Stamp-On equips a tangible interface in the form of a stamp, which is used as an input-device for visitors to show explanations on a mobile device such as an iPad. The explanations will give the corresponding information about exhibiting items with additional questions. By touching the screen of the mobile device with the Stamp-On near the corresponding item, she or he will get visual information. We have conducted a preliminary experiment with participants of school teachers in order to evaluate the effectiveness as an exhibition guidance system. The results have suggested that Stamp-On system is an attractive and effective learning aid for elementary school children visitors of a museum.

1 INTRODUCTION

Conventional mobile guidance systems in a museum consist of tailored sound- or video-based equipments. Therefore, their maintenance effort costs much. Once they have been set up, it was difficult to deal with the visitor diversity in terms of ages, knowledge, and/or interests. To resolve these difficulties, there have been an increasing number of studies in recent years on mobile guidance systems, which aims at flexible responses to various kinds of visitors. Such systems usually combine location sensors and mobile devices such as cell phones, smart phones, or iPads (Cahill et al., 2011; Kusunoki et al., 2005; Raptis et al., 2005; Rose et al., 2009; Suzuki et al., 2009; Yamaguchi et al., 2010; Yatani et al., 2004).

The interfaces of those existing mobile devices are, however, hard to be used by every visitor, in particular, young children. For instance, although their operation methods look simple, most of the operations require multiple steps to display the contents. Furthermore, operating and maintenance costs of such conventional guidance systems will cause severe issues from the management of the museums. To cope with these these issues, in this paper, we propose Stamp-On system, a learning game which has a tangible interface that emphasizes the physical form as a novel design of an input device for a mobile guidance aid in a museum. Stamp-On is able to handle visitors' diversity using contents made up of videos and photographs. Stamp-On system also contains an interface in a stamp form, inspired by actual stamps. The paper provides principles and overview of Stamp-On system, and gives a preliminary experimental results of the usability of the stamp form interface.

2 OVERVIEW OF Stamp-On

Stamp-on is a stand alone system run on an iPad with the newly developed stamp-shaped interface. The stamp equips plural small metal chips as are used in stylus pens. The metal patterns represent coded information related to the object to be explained. Compared with the exhibition support system in the literature in the references, Stamp-on is characterized by the following unique features:

1) As all the information is held in the iPad appl ications, it is not necessary to use any wireless networks.
2) To identify the exhibited object, they are only required to push the corresponding stamp on

iPAD. If we would use wireless networks, to distinguish different objects, the distances among them would keep more than one meter.

3) It is easy to set up at any exhibited space without special IT equipments.

Furthermore, compared with the research by Suga, et al., in which they utilize pipe shaped devices in order to move 3-d objects, the stamp interface in this paper is very easy to make. Stamp-on is the first system for such exhibition support task domains.

2.1 The Stamp Shape Interface

Figure 1 gives an overview of Stamp-On system. A tangible object in the shape of a stamp is physically attached to an exhibit (the rocks in Figure 1). By pressing this stamp on the iPad mini screen, the iPad mini acquires an ID, then the contents corresponding to this ID are displayed. The contents are installed on the iPad mini. The most important and unique feature of Stamp-On is its exceedingly simple content-matching by the attached stamp. Moreover, there will be no misidentification of exhibits as the stamp is physically attached to the exhibit.

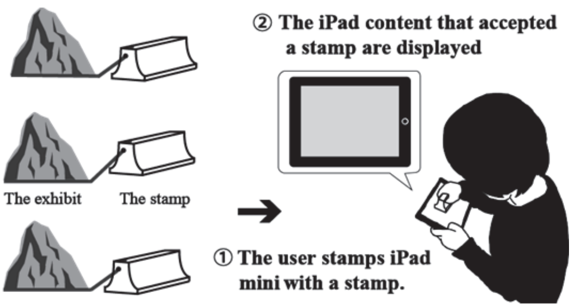

Figure 1: The overview of the Stamp-On system.

The stamp uses multi-touch technology used by the iPad and/or Android devices. For this study, 10 electrification patterns are configured on the bottom of the stamps to represent the corresponding IDs. When a user take the stamp and presses it on the iPad mini screen, the iPad mini detects the pattern, thus displays the contents associated with the exhibit (Figure. 2). As illustrated in Figure 3, the stamp is 30 mm high with a 40 mm * 100 mm rectangular base. To distinguish the top and bottom of the stamp, the top has engraved lettering. As an electric current runs through the stamp, aluminium tape has been used to the bottom as well as on the sides, as they come in contact with human skin.

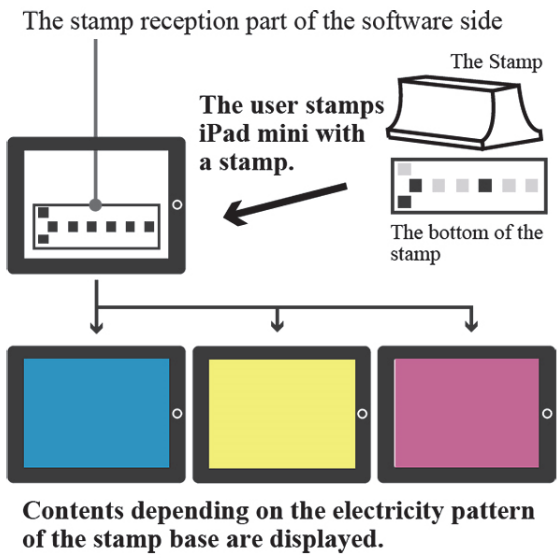

Figure 2: Relation among Stamp-on tags and iPad contents.

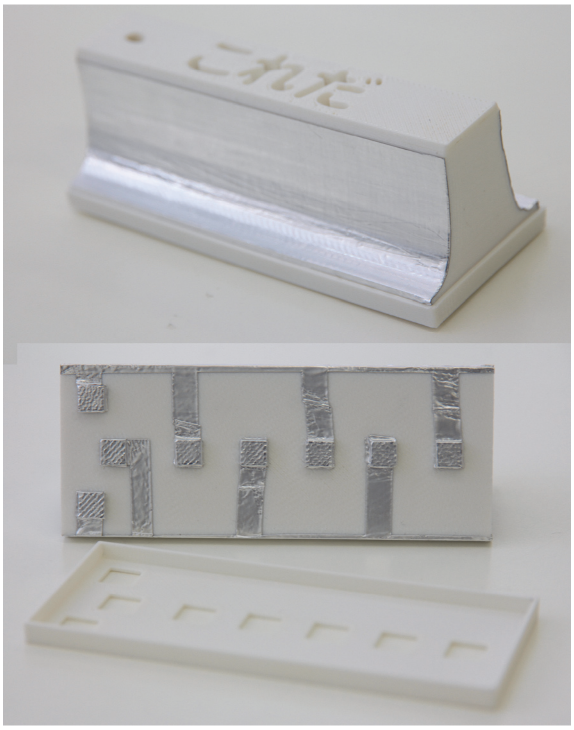

Figure 3: The shape of the stamp interface (upper photo) and patterns embedded in the bottom of the stamp (lower photo).

2.2 Explanation Contents

Figure 4 shows examples of the explanation contents incorporated in Stamp-On system. The contents consist of interactive explanations as quizzes. The quizzes are developed to identify nine typical types of rocks found around the Hyogo Prefecture, Japan. We are currently making contents good for school children. As shown in Figure 4, the touchable area with the same size of the bottom of the stamp is displayed on the iPad mini screen. By pressing the stamp on the touchable area, its ID is recognized, then corresponding contents depending on the ID are displayed. Specifically, the name of a rock the visitor observes and its characteristics are shown on the screen of the mobile device, then, the visitor is requested to find the rock among the exhibited items.

When the visitor presses the stamp on the rectangular 'reply' box on the content displayed, the answer is judged to be either right or wrong. If the answer is correct, further detailed information on that rock is displayed. Pressing the stamps and answering the quizzes encourages the visitor to have a look around and examine the rocks in more detail.

The questions have predetermined points and corresponding hints. When a user refers to the hint, however, her/his points are decreasing by the points. After answering each question, a user are requested whether she/he would like to add the stone information to her/his collections, if she/he would have enough points to get. Accordingly, let her/him observe the exibit better to avoid to decrease her/his points.

The software running on the iPad mini was implemented with Adobe Flash CS6.

3 PRELIMINARY EXPERIMENT

We have conducted a preliminary experiment on the usability of the Stamp-On system through questionnaires and interviews with elementary school teachers. We asked teachers to evaluate the system by imagining an educational trip to the museum for school children.

3.1 Questionnaire-based Evaluation

3.1.1 Purpose

The Stamp-On system evaluation specifically focused on the stamp usages.

Figure 4: Parts of iPad Contents.

3.1.2 Participants

The participants of the experiment are 15 elementary school teachers (45.4 years old on average) taking part in a workshop held by the Hyogo Prefecture Science Museum, Japan (Hyogo Prefecture Museum of Nature and Human Activities).

3.1.3 Task

The questionnaires are designed to evaluate the usability of the system. For all questions related to the usability, the participants are asked to grade five possible responses ranging from 'I completely agree' to 'I completely disagree.'

The questions use the term 'game', because the Stamp-On system is presented as a game, with which one has to find the rocks based on the provided hints. Six questions focused on the stamp as a tangible interface.

These questions include such ones as "Did you think this game was interesting?", "Do you consider the system of pressing a stamp tied to an exhibit onto an iPad mini a good one?", "Would you want to use this kind of system as a teaching resource?", "Did you find the way the stamp was used easy to understand?".

3.1.4 Procedure

The experiment is conducted as a game, by which participants are required to find nine types of rocks out of the twelves ones on a display (Figure 5). The time required was approximately 20 minutes. Participants are then asked to answer individual questions on the usability. This took approximately 3 minutes. The evaluation experiment was conducted on August 22, 2013.

Figure 5: Snapshot of the experiment.

3.1.5 Results

Table 1 shows the head-count distribution of the responses. Most participants respond a positive answers for all questions. We investigate response trends after separating the responses obtained from the questionnaire surveys into two groups: positive responses including "completely agree" and "agree" and negative responses including "somewhat disagree" and "completely disagree." Fisher's exact tests (1×2) showed statistical significance at a 1% level for the all items.

3.2 Post-Interview Evaluation

3.2.1 Purpose

The purpose is to obtain a qualitative results from participantts regarding the effectiveness of the stamp form interface of the Stamp-On system.

3.2.2 Participants and the Task

The participants were two randomly selected from respondents of the previously mentioned

Table 1: Stamp-On system usability test results.

	5	4	3	2	1
(1) Did you think this was an interesting game?**	11	3	0	1	0
(2) Do you think this game will be popular with children?**	7	5	2	1	0
(3) Did you think the system where you press a stamp tied to an exhibit onto an iPad mini is a good one?**	7	6	2	0	0
(4) Do you think you would want to use this kind of system where exhibits and device are linked as a teaching resource?**	7	6	2	0	0
(5) Did you find the way the stamp was used easy to understand?**	5	6	3	0	1
(6) Did you think pressing the stamp on the device was fun?**	10	5	0	0	0

$^{**}p<.01$, 5= completely agree, 1= completely disagree questionnaire. The evaluation task is to ask for opinions about the system's effectiveness. The question is given: "What impression do you receive after using the stamp?"

3.2.3 Procedure

We have conducted semi-structured one-on-one interviews, just after the Stamp-On system experiment. The interviews takes approximately 5 minutes per participant.

3.2.4 Results

Table 2 shows the results of the interview-based survey. Firstly, positive answers ('interesting', 'fun') are obtained from the participants. Some participan emphasizes the significance of the interface when they stand in front of the rocks, the exhibit, and pressing the stamp on the device. The following statements are given by them: "With the stamp, I always stand in front of the rocks," "Actually touching the rock and then pressing the stamp is easy to understand." They indicate the stamp's potential as an effective intermediary between a child and an exhibit.

Table 2: Participants' replies in the interviews.

Participant A: Firstly, I thought the system was interesting and fun. Pressing a stamp on something, that kind of thing is enjoyable. I think it is great that there are movements involved, it will keep children interested and I thought that it was enjoyable. The important thing is that you have to stand in front of the rocks to be able to do it, is it not? When you use a finger, you can just tap anything while looking at the rocks from afar, but this system has a definite advantage because with the stamp, you have to stand in front of the rocks and press it on the device.
Participant B: Pressing a stamp on something is something children like, as well as me, so my impression of the stamp was that it was an interesting idea. Actually touching the rocks and pressing the stamp that is there is easy to understand, I thought. Because you want to get the questions correct, something you would not be able to do unless you observe it in more detail, I think that the quiz allows for even more in-depth learning.

4 CONCLUSIONS

This paper has describes the design principle of Stamp-On system and its preliminary experiment. The Stamp-On system is characterized by a tangible interface in a stamp form, which is easy to use. Results of the experiment have shown that the Stamp-On system is an attractive and effective learning aid for school children at a museum.

Our future work include the improvement of the interface focussing on the stamp, further experiments with school children, and development of new contents and support functions for a variety of visitors.

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Barbie Bungee Jumping, Technology and Contextualised Learning of Mathematics

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Keywords: Mathematics Education, Post-primary Education, Technology, Contextualised Learning.

Abstract: There is ongoing debate about the quality of mathematics education at post-primary level. Research suggests that, while the capacity to use mathematics constructively is fundamental to the economies of the future, many graduates of the secondary-school system have a fragmented and de-contextualised view of the subject, leading to issues with engagement and motivation. In an attempt to address some of the difficulties associated with mathematics teaching and learning, the authors have developed a set of design principles for the creation of contextualised, collaborative and technology-mediated mathematics learning activities. This paper describes the implementation of two such activities. The study involved 24 students aged between 15 and 16 who engaged in the activities for 2.5 hours each day over a week long period. Initial results indicate that the interventions were pragmatic to implement in a classroom setting and were successful in addressing some of the issues in mathematics education evident from the literature.

1 INTRODUCTION

Research suggests that, while the capacity to use mathematics constructively will be fundamental to the economies of the future, the view that many graduates of the secondary-school system have of the subject is fragmented and lacking in context, leading to issues with engagement and motivation (Gross et al., 2009; Grossman, 2001). This study looks at how the affordances of readily available digital technology can be exploited to create mathematical activities that address common issues in mathematics education.

There is strong evidence in the literature that an approach to mathematics education encouraging contextualised, collaborative solving of mathematical problems is beneficial (Hoyles and Noss, 2009; Olive et al., 2010). Following an extensive review and analysis of the recent literature on technology-enhanced mathematics learning interventions, the authors have devised a set of guidelines to assist teachers in the design and delivery of such interventions, a number of which have been piloted in an experimental learning environment in the authors' institution. Following from these pilot interventions, a larger scale set of activities has been implemented in a conventional school setting, the preliminary results of which will be discussed in this paper.

The overarching research in which this study is situated follows a design-based methodology (Anderson and Shattuck, 2012; Mor and Winters, 2007), in which a series of technology-mediated mathematical tasks are developed in tandem with the theory and principles that underpin them. The design principles for the activities are evolving from the ongoing literature review and classification process, in conjunction with analysis of empirical findings from teaching experiments in natural and exploratory settings.

This paper is consists of two main parts. In order to contextualise the current research within the broader field, a literature review and background to the current work is presented. The paper then describes a week-long intervention in a conventional co-educational school setting, involving 24 mixed-ability students. Preliminary findings from the intervention will be discussed, along with its impact on the design principles and future work.

2 BACKGROUND

In order to ground this research within the wider context, this section includes a literature review of the general issues in mathematics education, as well as specific topics relating to the use of digital technology in the field. A synopsis of the development and analysis of the classification system, and the development of the design principles and related activities is also provided.

2.1 Issues in Mathematics Education

There is an unfortunately prevalent view of mathematics as a collection of unrelated facts and rules, and a related belief that learning mathematics involves memorisation and execution of procedures leading to unique, correct answers (Ernest, 1997); an assumption that mathematics is "hard, right or wrong, routinised and boring" (Noss and Hoyles, 1996, p. 223). This formal, abstract and assessment driven approach to mathematics education remains dominant in many countries (Ozdamli et al., 2013) contributing to behaviourist and didactic tendencies in teaching and learning, with an emphasis on content and procedure over literacy and understanding. In this context, mathematical creativity is not prized and students are rarely encouraged to seek out their own alternative solutions (Dede, 2010). The authority of the teacher is perceived as absolute, their job to transmit information to the students.

Efforts to address some of these issues have met with limited success. Attempts to introduce problem-solving and realistic context to mathematics teaching and learning are particularly pertinent to this research. However, as Boaler (1993) suggests, such problems are frequently uninteresting from the point of view of the students as they are generally formulated in such a way as to be routine problems with just a veneer of the 'real-world'. In an attempt to reduce complexity, the activities are overly well-defined, furnishing all of the information required to solve the problem, without excess. The learner is reduced to following the standard procedure of inserting data into appropriate formulae in an attempt to get the 'correct' answer (Dede, 2010).

2.2 ICT and Mathematics Education

The use of digital technologies in mathematics education has the capacity to open up diverse pathways for students to construct and engage with mathematical knowledge, embedding the subject in authentic contexts and returning the agency to create meaning to the students (Drijvers, Mariotti, Olive, & Sacristán, 2010; Olive et al., 2010).

Noss and Hoyles (1996) propose that technology has the potential to bring meaningful mathematics into the classroom. It can facilitate an emphasis on practical applications of mathematics, through modelling, visualisation, manipulation and more complex scenarios (Olive et al., 2010).

Many authors contend however, that although use of technology in the classroom is increasing, its potential to enhance the learning experience lags behind its implementation in the classroom (Geiger et al., 2010; Hoyles and Lagrange, 2010). While students may engage in the creative use of digital technologies on a daily basis, they do so less frequently in an educational context (Oldknow, 2009; Pimm and Johnston-Wilder, 2004).

Jonassen, Carr, and Yueh (1998) contrast technologies that attempt to instruct the learner, with what they describe as *mindtools* - technological tools that students learn with, rather than from – which support knowledge construction by engaging them in critical thinking. Thus technology becomes a mediator of the learning experience, facilitating reflective, discursive and problem-solving skills.

In this research, we are attempting to facilitate the use of digital technology as 'mindtools' to encourage the development of the desired skill set by scaffolding implementation through the emerging design principles.

2.3 Analysis of Empirical Interventions

At the outset of the research process, it became clear that a system of classification would be beneficial in order to put a framework on the current trends in the literature relating to technology usage in mathematics education.

An ongoing, systematic review of recent literature in which technology interventions in mathematics education are described is used as the foundation of such a system of classification, a detailed analysis of which can be found in (Bray and Tangney, 2013b). Trends emerging from the analysis of the classification are used in conjunction with a broader literature review, to inform a set of design principles for the development of interventions in the field.

Through the classification it is evident that a wide range of technologies are being researched in different environments, with different agendas and from varying theoretical standpoints. What most interventions have in common is a trend towards social constructivism and a desire to create engaging environments in which the technology is used to increase the students' interest, motivation and performance. The pervasive perception of mathematics education emerging from the papers focuses on understanding of relations, processes and purposes, as opposed to the requirement to learn a fixed body of knowledge. There is a move towards connection, coherency and context as important aspects of mathematics education that can be facilitated by technology.

2.4 Emerging Design Principles

Analysis of the classified papers, along with a general literature review, provides the theoretical foundations for a set of design principles for the development of innovative, technology-mediated, mathematical activities. Using a first iteration of the design principles, a number of activities have been devised and trialled in an exploratory environment. The results of these pilot studies have fed back into theoretical foundations of the research, leading to refinement of the classification and design principles. Our intention in developing these guidelines and activities is to increase student engagement and motivation with mathematics and to increase teacher awareness of how to support learning within these scenarios.

The design principles resonate with a view of mathematics as a problem-solving activity and of mathematics education as involving students in constructing their knowledge via the social formulation and solution of problems. A need for the development of tasks that are transformed through the use of technology, providing contexts that are relevant and of interest to the students, and which have compelling goals is evident (Confrey et al., 2010; Laborde, 2002; Oldknow, 2009). Technologies that outsource the burden of computation have proven to be an interesting area of research, not only improving speed and accuracy of students engaged in procedural tasks, but also allowing increasing emphasis to be placed on meaning as opposed to routine operation (Geiger et al., 2010; Oates, 2011). The use of a variety of accessible, free technologies is an important issue, not only due to matters of equity, but also to engender flexibility amongst students and teachers (Oldknow, 2009; Sinclair et al., 2010).

2.5 Initial Learning Activities

A number of activities have been designed in accordance with the design principles, and have been piloted with groups of students and teachers in an exploratory learning centre, Bridge21, at the authors' institution. The centre is designed to support a model of collaborative, technology-mediated and project-based learning (Lawlor et al., 2010). The teacher is seen as orchestrator rather than director of the learning, building on a model of peer learning and collaboration originating in the patrol system of the World Scout Movement (Bénard, 2002). Post-primary students are released from school to attend workshops in the centre, of between four and five hours duration.

The activities that have been tested to date include The Human Catapult (projectile motion, functions, angles and velocity) and The Scale Activity (estimation, orders of magnitude and scientific notation) described in (Bray and Tangney, 2013a), as well as Probability and Plinko (independent events, normal distribution, Pascal's triangle, probability, binomial distribution), the Pond Filling Activity (problem-solving, estimation and volume) (Tangney and Bray, 2013), and the Barbie Bungee (collecting, representing and analysis of data, linear functions, line of best fit, correlation, extrapolation). The interventions have provided data relating to the practicality of the tasks and a starting point from which to begin the iterative process of development.

The results of the pilot interventions have provided the justification for further investigation in authentic classroom environments. This study reports on initial trials in an actual classroom setting.

3 THE INTERVENTION

The school in which the study took place is a co-educational private school in an urban area and is one of a network of schools cooperating with our institution in an attempt to adapt the Bridge21 model for use in mainstream schools. These schools are favourably disposed towards a collaborative, technology-mediated approach. In addition, participating students have had prior exposure to workshops in which they have been introduced to the Bridge21 model of learning, thus increasing their understanding of the processes involved in teamwork and project-based learning. When it comes to tackling the mathematical activities, they should therefore be well versed in the methodology and in a position to concentrate on the task.

The school in this study has re-modelled its approach to teaching and learning in line with the Bridge21 methodology. In light of this, the year 10 (age 15/16) timetable has been restructured in order to accommodate a 2.5 hour block of curriculum-related project work in the middle of the day. For the Contextual Mathematics intervention the 1st author had access to students for this project block each day for one week. During this period, the author acted as primary teacher, or facilitator, with one classroom assistant. The class consisted of 24 students (12 male and 12 female), of mixed ability, who were assigned to 6 groups of 4 students each. The groups were assigned in order to balance abilities and gender. The environment was made up of two adjoining rooms with double doors between them. Each team had an allocated area, or workstation, with access to at least one computer, where they could work together. Laptops, cameras and other props were provided by the researchers. Students had permission to leave the school premises when the activity required.

3.1 Methodology

As described in the introduction, the overarching research project employs a design-based methodology (Anderson and Shattuck, 2012; Mor and Winters, 2007) whereby the mathematical activities and the theory that underpins them are developed in a complimentary and iterative manner. Data from individual case studies, collected by way of observation, semi-structured interview and questionnaires, helps to inform and refine both the design principles and the activities themselves.

The Mathematics and Technology Attitudes Scale (MTAS) (Pierce et al., 2007) was used as a pre- and post-questionnaire, giving a quantitative measure of confidence levels in mathematics and technology, behavioural engagement, affective engagement, and attitudes to using technology in mathematics. Qualitative data was gathered from student journals, written comments and a semi-structured interview with 5 of the 6 team leaders. At this stage only preliminary results are available from the qualitative data as the process of coding and theming is in its early stages.

3.2 Outline of the Activities

In this section, an outline of the weeks' activities is provided. Every day followed the same general structure, based on the learning model developed in the Bridge21. Each session began with an initial plenary discussion in which previous work was reviewed and the mathematical problems and activities for the day were presented. This was followed by a team planning, after which team-leaders met to discuss possible solution strategies with the facilitator and assistant. Once the plans were approved, the groups were free to implement them. As the teams worked, the facilitators interacted with the students, scaffolding their exploration of the mathematics and technology. At the end of the session, each group presented their work, discussing what individual team members had been responsible for, what had been accomplished, and what mathematics they had understood. After a final whole group discussion, take-home problems were assigned. These were short questions designed to be thought provoking and interesting, and requiring the students to be creative with their solving strategies.

The first day consisted of warm-ups, team-building activities and Fermi-type problems. These are exercises in estimation and approximation, encouraging problem-solving and mathematical creativity. The 'correct' answer is not the primary goal, and many approaches to the solution are acceptable. Examples used include the following.

- Estimate the number of blades of grass in the local park.
- Estimate the average walking speed of people outside the local park.
- Estimate how many seconds old you are.

The teams had permission to use the internet, giving them access to Google maps, grid overlay tools etc. Each team was also furnished with a measuring tape and a camera.

Day 2 marked the beginning of the program of activities that were the primary focus of this study. Although the concept of a Barbie Bungee is not a new in mathematics education, embedding it a loosely scaffolded, technology-mediated and team-based environment has lent it a novel and innovative perspective.

Each group was provided with a Barbie doll, a box of rubber bands, a camera, a laptop with the free video analysis software Kinovea and a spreadsheet program. They were asked to estimate the number of rubber bands needed to give Barbie an exhilarating, but safe jump, from a first floor window. Trial and error was not permitted, and they were not initially allowed to leave the room to measure the distance of the fall. Particular incentive was given by making the testing of their hypotheses into a competition. The groups used diverse methods of tying the bands and adding weights to the dolls. All but one of the teams made use of the available digital technology to video the bouncing Barbie in order to accurately capture the distance she dropped. Each group recorded their data in a spreadsheet and used the capabilities of the technology to create a scatter plot and generate a line of best fit. Most of the teams had reached this point in time for the wrap-up session at the end of the day.

Day 3 began with a very interesting discussion about functions, correlation, causality and extrapolation. The groups then estimated the distance the Barbie would need to drop from the first floor window and returned to the functions that described their line of best fit. Once the dolls were attached to their bungees, the knockout competition began and two by two the teams competed to see whose doll got closest to the ground without hitting it.

Figure 1: Barbie Bungee Competition.

Once the winning team was decided and the prizes were distributed, the discussion regarding the next activity began.

The Human Catapult activity is an investigation into projectile motion. Teams use an oversized slingshot, foam balls, cameras and the free video analysis software Tracker (www.cabrillo.edu/~dbrown/tracker), and GeoGebra (www.geogebra.org), to investigate concepts such as functions, angles, rates of change and velocity.

After a plenary session in which the optimal approach to video recording for the purposes of generating quadratic functions was discussed, the groups spent the second half of the 3rd day in the local park recording their team members using the catapult to fire a foam ball.

The plenary session that began the 4th day highlighted the mathematical connections that underpin the Barbie and Catapult activities. Although the methods of data collection differed – manual measurement and plotting of points on a graph, or automatically generated functions through frame-by-frame video analysis – the approach of using the line/parabola of best fit for modelling and generalisation was common to both activities. In addition, the concept of correlation and causality that had been introduced with the Barbie activity was explored in significant depth through the graphs of the functions generated by the catapult. The initial graph discussed was the pictorial representation of the flight of the ball through the air, in which the x-axis represents horizontal distance and the y-axis represents height.

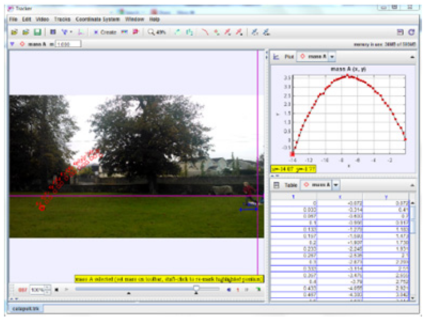

Figure 2: Tracker Generation of Initial Graph.

On discussing whether there was a causal relationship between these two variables, one of the students remarked: "*well, if the distance is counted as time there is*", which allowed for the deconstruction of the original graph into the two more meaningful graphs of *height with respect to time* and *horizontal distance with respect to time*.

The groups used the video analysis and best-fit functionality in Tracker to generate relevant functions, which were then analysed in GeoGebra. After initial technical difficulties, most of the teams managed to generate the functions and begin their modelling. While calculating the angle of projection and maximum height were straightforward tasks, estimation of the initial velocity of the ball is quite an involved concept and this part of the activity was left for the final day.

Once the concept of initial velocity and possible approaches to its calculation were explained, the teams were given time to try to work it out before using a simulation on phet.colorado.edu to gauge the accuracy of their mathematical model. Once again, a competition was used to incentivise the efforts and a final showdown, in which the actual distances were compared against the simulated distances, was used to judge the endeavour. Once preparation of the final presentations was complete, the groups took turns to talk about what they had achieved.

3.3 Preliminary Analysis of Results

While results presented in this section are in the early stages, preliminary analysis indicates some interesting outcomes.

21 of the 24 students completed both a pre- and post-questionnaire, which was designed to highlight changes in their attitudes to mathematics and technology, and their levels of behavioural and

affective engagement over the course of the intervention. The questionnaire used was the Mathematics and Technology Attitudes Scale (Pierce et al., 2007) – a 20 item questionnaire with a likert-type scoring system that measures mathematical confidence, technological confidence, behavioural engagement, affective engagement and attitude to using technology in mathematics. There was a small increase in behavioural engagement and in attitudes to using technology in mathematics, and a slight decrease in mathematical and technological confidence. However, a 6% increase in affective engagement was recorded.

As short-term significant changes are hard to achieve, and these changes have not yet been tested for statistical significance. However, from the qualitative data it seems that the drop in confidence levels relates to the change from the typical, formulaic approach to mathematics education to the use of messy data with no absolute "correct" answer to the activities.

At this stage of the analysis, we have decided to use a word-cloud of the most frequently recorded 50 words of 4 or more letters to provide a feel for the qualitative data that has emerged from the intervention. This graphical representation of word frequency is not meant as a substitute for traditional content analysis – which is ongoing at the time of writing – but as a visually rich way to enable readers to get a feel for the data at hand (Joubert, 2012; McNaught and Lam, 2010). In a word-cloud the size of the word relates to the number of times it occurs. The data was gathered from student post-questionnaire comments, individual journals, and from the transcription of a 25 minute, semi-structured focus group interview. Before running the word frequency analysis on the data, usage of the word "like" as a vocalised pause was removed from the transcript of the interview so that it would not pollute the data. This usage of the word is common among teenagers as a meaningless interjection, to keep conversation flowing.

The relatively large size of positive attitudinal words such as "like" (used to represent enjoyment), "enjoy" and "interesting" support the increase in affective engagement recorded in the quantitative data. Additional support is found in quotes such as:

- *"I found using maths in a practical environment and in everyday life interesting and enjoyable.*"
- "*It was definitely better than normal school maths. It was far more engaging.*"
- *"I felt that leaving us to it and letting us go out was great."*

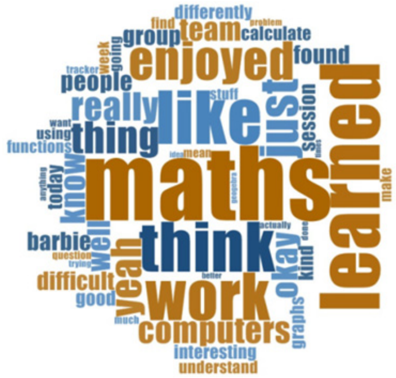

Figure 3: Word Cloud.

- "*I liked this week; it did not feel like maths in a way, it felt like fun. It felt different from school maths but I still learned things.*"

Even students with negative initial attitudes seemed to have a positive experience:

- "*[I am] shaken in my absolute use of the term 'hate' [relating to mathematics] and more on the side of 'mildly dislike'*".

The focus group interview involved team leaders from five of the six groups (one team was unavailable) and the 1st author, and shed light on many of the positive and negative aspects of the intervention. One student felt that the aim of the approach was to create a more engaging and involving way to learn mathematics, encouraging students to "*think outside the box*". When queried as to whether he meant problem solving, he replied: "*it's not just simple problem solving, like when you get this big long-winded question, and... you know it's simultaneous equations, or you know it's going to be graphs. This is like, it doesn't tell you what it is, you just have to figure it out yourself*". Another student found using the facility of the technology to outsource the calculation was very beneficial: "*using the computers was really handy, because it meant that I could understand it and have fun with it, without having to stress about getting it wrong*". All of the students agreed that the emphasis was more on understanding of concepts as opposed to procedures and content. When questioned about the development of new understanding, a number of them pointed out that prior to the intervention, they had not realised the extent of relationships between different areas of mathematics, and how, in many cases, what are often presented as diverse topics are simply different modes of representation. Others had developed a deeper understanding (or in some cases 'an' understanding) of functions.

There were contrasting reactions to the usage of technology in the groups. Some of the students felt that it gave them freedom to understand and manipulate the mathematics, while others preferred more concrete, hands on activities: "*I didn't like… when we were using GeoGebra. That's why I liked the Barbie thing, because you can hold it. I liked seeing it in my hands and being able to pull it and see what happens and that, but on a computer it seems very abstract*".

4 DISCUSSION

While digital technology has the potential to open new routes for students to construct and comprehend mathematical knowledge and new approaches to problem-solving, this requires a change in the pedagogical approach in the classroom in terms of student engagement with learning (Drijvers et al., 2010). Olive et al. (2010) highlight that "it is not the technology itself that facilitates new knowledge and practice, but technology's affordances for development of tasks and processes that forge new pathways" (p154).

The need to conduct research into the design and development of tasks and activities that provide engaging environments, in which the mathematics are seen as relevant by the students, with goals that they find compelling (Confrey et al., 2010; Laborde, 2002; Oldknow, 2009) is the motivating factor for this work. In this study, technology has facilitated research, data gathering and analysis, outsourcing of computation and mathematical modelling, all of which have permitted a level of engagement with mathematical concepts that would not otherwise have been possible. This is reflected in the increase in affective engagement recorded in the MTAS scores, but perhaps more significant is the sense of student ownership and the understanding of connections, mathematical context and relevance that is evident from the students' qualitative responses.

Kieran and Drijvers (2006) contend that mathematical tasks that make use of technology should not be studied without also paying careful attention to the classroom environment and the role of the teacher. Flexibility with regard to routine and environment are necessary in order to fully exploit the potential of technology in the teaching and learning of mathematics; the block structuring of the timetable in the School in which the study took place facilitated real student engagement with the activities. If the activities were to be conducted within the confines of a more conventional timetable, with periods of between 35 and 90 minutes, the experience would have been more fractured and, while it may still be possible, it is unlikely that the same level of engagement would have been achieved.

Means (2010) points out that higher learning gains are associated with classrooms in which an established routine is in place for moving between technology-mediated and traditional activities. Orchestration of the classroom and technological difficulties relating to network access and up-to-date software emerged as an issue that needs serious consideration and contingency planning before further interventions of this kind are undertaken.

The week-long intervention in an authentic school setting has provided a positive view of the approach to integrating technology in mathematics education proposed in this research. The initial results indicate that there is real potential for increased engagement and conceptual understanding emerging from participation with activities designed in accordance with the design principles

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Braille Vision Using Braille Display and Bio-inspired Camera

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Keywords: Disabled Users, Braille Display, Bio-inspired Camera, Computer Vision, Image Processing.

Abstract: This paper presents a system for Braille learning support using real-time panoramic views generated from the novel smart panorama camera 360SCAN. The system makes use of the modern image processing libraries and state-of-the-art features extraction and clustering methods. We compare the real-time frames recorded by the bio-inspired camera to the reference images in order to determine particular figures. One contribution of the proposed method is that image edges can be transformed to the presentation on Braille display directly without any image processing. It is possible due to the bio-inspired construction of camera sensor. Another contribution is that our approach provides Braille users with images recorded from natural scenes. We conducted several experiments that verify the methods that demonstrate learning figures captured by the smart camera. Our goal is to process such images and present them on the Braille Display in a form appropriate for visually impaired people. All evaluations were performed in the natural environment with ambient illumination of 200 lux, which demonstrates high camera reliability in difficult light conditions. The system can be optimized by applying additional filters and features algorithms and by decreasing the rotational speed of the camera. The presented Braille learning support system is a building block for a rich and qualitative educational system for the efficient information transfer focused on visually impaired people.

1 INTRODUCTION

Though visually impaired people have quite good developed computer interfaces for Braille code (Jiménez et al., 2009) they have very limited access to image information. Smart cameras provide application-specific information out of a raw image or video stream. Real-time smart camera operation areas can be extended for Braille education task. Until now, reasoning has not been applied to smart camera output. Currently the verification and analysis of camera output are usually carried out manually and are not used for further analysis or processing. The rich information from images is not evaluated and there are no automated methods to estimate the content of current natural scene, to detect objects observed during camera use, or to validate the camera output. There is a need for digital preservation methods to handle such information and make it useful for visually impaired people.

In this work, we described a system for the automated Braille educational support with a specific smart camera (the AIT 360SCAN presented in Figure 1) that could be used to enhance the accessibility to graphical information for visually impaired people and efficiency of its understanding and process-

Figure 1: The bio-inspired panoramic smart camera 360SCAN.

ing. The paper (Belbachir et al., 2012) provides a detailed description of the newly designed smart camera 360SCAN for real-time panoramic views. The main contribution described in this paper is a real-time image analysis approach focused on needs of visually impaired people with algorithms that provide automatic information extraction and support methods for graphical information processing and presentation. In order to implement image processing for natural scenes we apply duplicate detection and object recognition to recorded images of smart camera output. For example, our system carries out an initial image processing by object detection and searching for duplicates against a set of reference images like triangle or circle before making presentation of the detected form in a Braille appropriate format using dot matrix.

The paper is structured as follows: The next section gives an overview of related work and concepts. In the third section we describe the Braille education system concepts and our algorithm exposed in a workflow. In the fourth section experimental setup and evaluation results are presented. In the last section concluding remarks and the outlook on planned future work is given.

2 RELATED WORK

Educational devices for Braille users currently are limited by several Braille displays due to very high price of Braille display. One of the graphical Braille displays that is in production is described in (Matschulat, 1999). The display area consists of a matrix 16 to 16 dots with 1mm distance between taxels. The advantage of this piezoelectric VideoTIM3 device is its high speed (24 frames per second), strong stroke, robustness and ability to demonstrate different shapes even if its resolution is not very high. The device consists of a hand-held conventional video camera and the main unit with the tactile display. But this technology is focused on document reading with your fingers and is not appropriate for another kind of images like natural scenes. This device is pretty large, heavy and expensive and such technique requires training.

In HyperBraille project was developed a graphics-enabled display for blind computer users (Prescher et al., 2010), (Erp et al., 2010). This display is designed to increase the amount of information percievable to blind computer user through both hands and enables graphical information to them. Besides high cost of this device it requires development of special software and focuses of standard Office and Internet

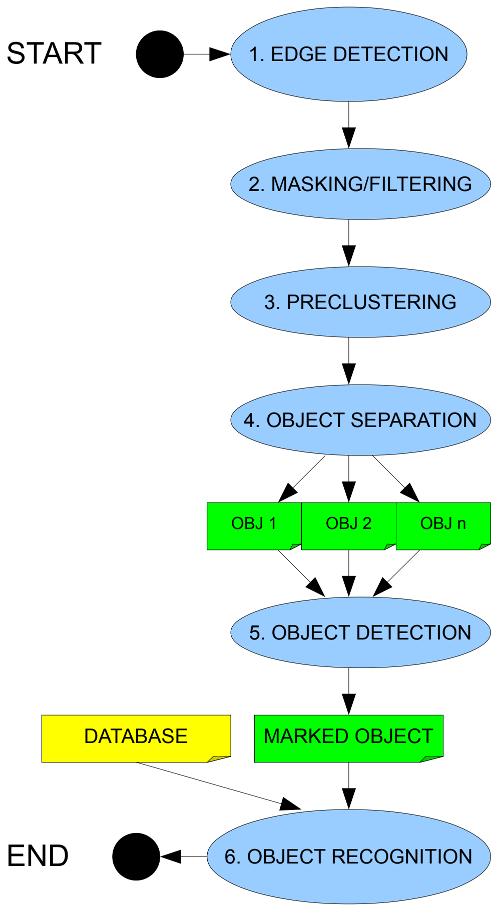

Figure 2: A workflow for object detection from recorded image.

applications.

The developers (Zeng and Weber, 2011), (Zeng and Weber, 2010) of project Tangram make use of HyperBraille device for graphical presentations. They developed education concepts and standardised document formats and use device extended by audio information. Therefore the main focus of their research is in creation of standards, educational concepts and software for existing device.

The advantage of our approach is that images from natural scenes are produced by a similar to human eye low cost smart camera with low data rate and high dynamic range. The output of this camera can be directly presented by the small Braille module in form of dot matrix but also can be processed, analysed (see Figure 2) an presented as required by Braille user.

A number of approaches deal with object detection from images and video. Many of these approaches are limited to text detection. For example, the efficient algorithm proposed in (Epshtein et al., 2010) uses the idea of detecting the width of character strokes. This method is very efficient for text

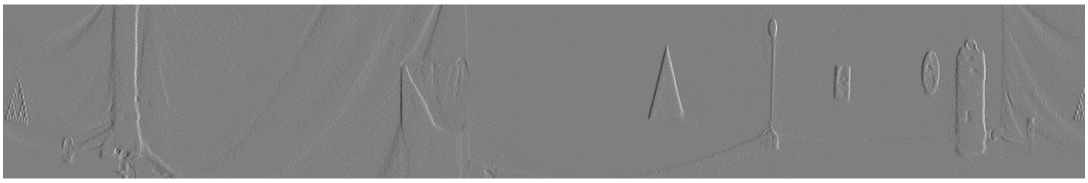

Figure 3: Event map generated by 360SCAN.

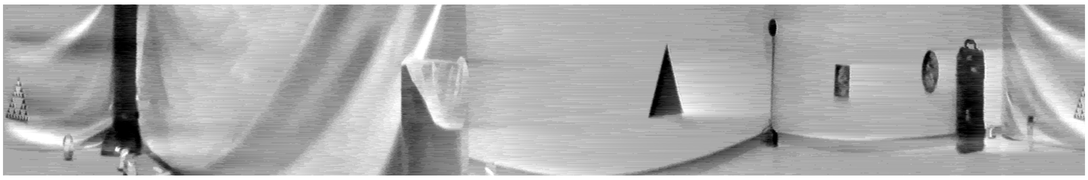

Figure 4: Reconstructed grayscale image from the event map.

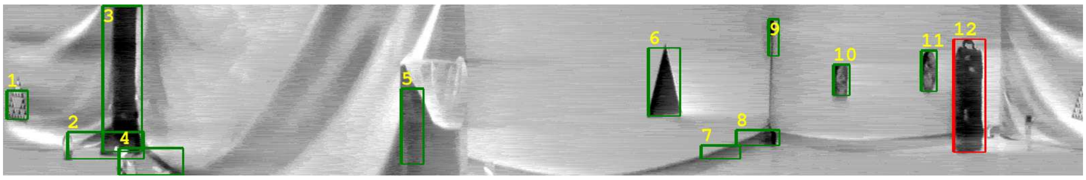

Figure 5: Detected objects.

recognition but do not solve the problem of duplicate search. A multiresolution approach (Cinque et al., 1998) for page segmentation is able to recognize text and graphics by applying a set of feature maps available in different resolution levels. This method breaks down an image into several blocks that represent text, line-drawings and pictures. However, too much additional analysis effort is required to compare the shapes provided by our smart camera. The AIT *matchbox* tool (Huber-Mörk and Schindler, 2012), developed for the SCAPE project[1], is based on the OpenCV library and implements image comparison for digitized text documents. The similarity computation task is based on the SIFT (Lowe, 2004) feature extraction method. This tool demonstrates high accuracy, good performance and provides duplicate search and comparison of digitized collection but is limited for text in images and is too slow to be applied to the smart camera domain.

In order to meet the requirements of quality control for our smart camera, we use image processing application based on the ImageMagick (Salehi, 2006) tool and PSNR metric. The application compares the camera output (see Figure 3-4) to a reference image collection in order to detect objects (see Figure 5) and to analyse the surrounding environment. This tool extends the functionality of *matchbox* for the domain of smart cameras with the ability to analyse images and video frames including segmentation. This application could be reused for the domain of digital preservation for Braille domain e.g. detection of shapes, forms, text blocks and for similar tasks.

[1]http://www.scape-project.eu/

3 BRAILLE EDUCATION SYSTEM CONCEPTS

With increasing volumes of graphical data produced by smart cameras, data analysis plays an increasingly important role. The figures of interest should be detected. In order to carry out this detection, we conduct an image analysis according the object detection workflow shown in Figure 2. Our hypothesis is that we can detect figures of interest applying image processing algorithms. We assume that the reference images stored in database will have significant similarity with objects extracted from recorded image. In order to meet these expectations, we analyze images for duplicates using the PSNR metrics and applying a workflow for duplicate search to ensure the correct object detection. In database we store figures of interest for particular educational task.

We started workflow with edge detection using event map 3 created by camera. In the second step we employ filtering for required pixels or masking if required for the reconstructed greyscale image 4. Then we applied pre-clustering employing parameter like pixel distance and cluster distance. The object separation occurred using clustering with parameters like

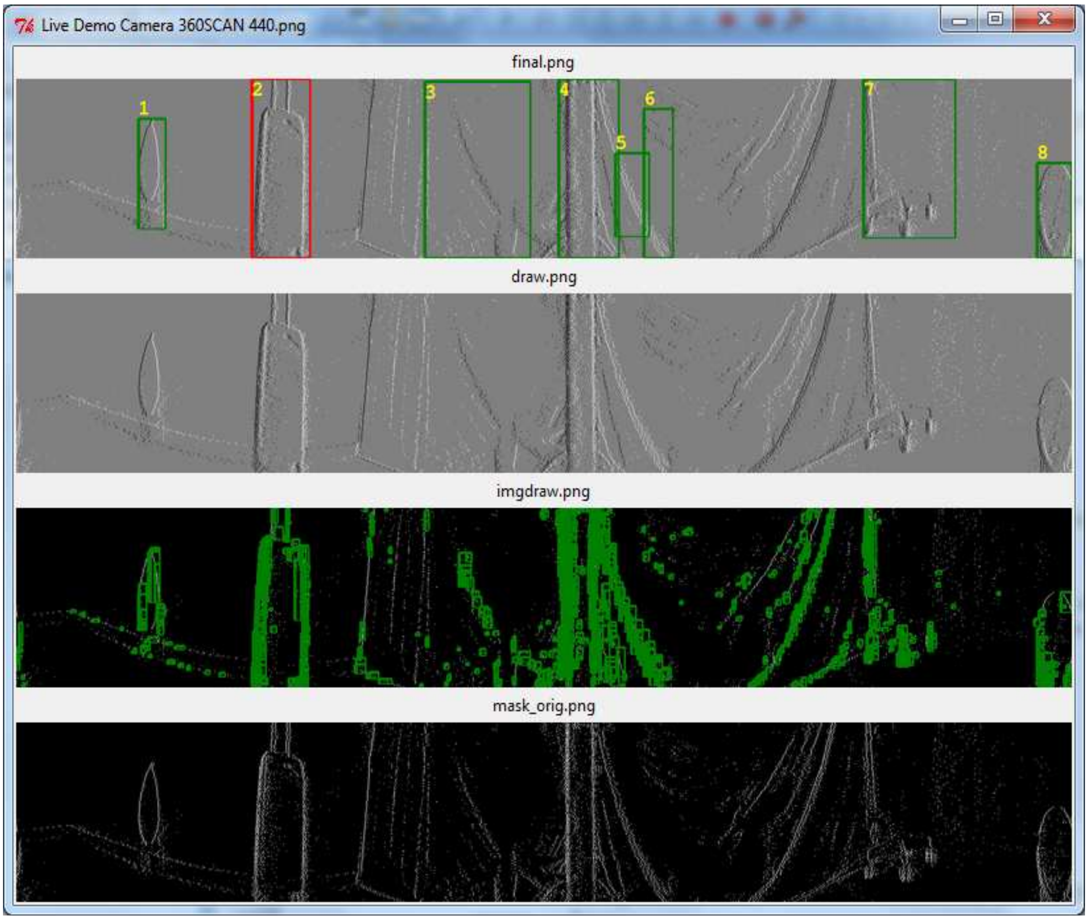

Figure 6: The bag recognition sample.

pixel distance, cluster distance, edge density, evaluation steps on X and Y axis, min cluster size, cluster dimension filter. The output of object detection step are objects marked by green rectangle 5. We alse depicted object number by yellow colour. Among the detected objects we searched for objects of interest and performed object recognition applying image comparison. E.g. PSNR metric and ImageMagick.

4 EVALUATION OF THE 360SCAN IMAGE PROCESSING

A sample application of our approach for bag detection is depicted in 6. The algorithm for that was written in Python 2.7 and given figure demonstrates output of the program.

In this case according to the above described workflow we masked the original raw image (draw.png). In mask orig.png white dots demonstrate dark areas of the raw image and black colour shows hell areas in the raw image. Then in imgdraw.png we filter and cluster detected pixels in order to separate possible objects. Finally in final.png we mark detected objects with green rectangles, depict object number by yellow number and recognized objects by red rectangles. Therefore found bag is marked by red rectangle and has number 2 in this case.

A vertical resolution of 360SCAN camera is 256 pixel. Therefore for 16 to 16 pin-matrix we should compress raw information to required size applying Equation 1.

$$\begin{aligned} G_{n,m} &= \{a_n, b_m\}, n \in \{0,1,\ldots,15\}, m \in \{0,1,\ldots,15\}, \\ p &= 16, \\ a_n &= \frac{1}{p}\sum_{k=0}^{p-1} x_{pn+k}, \\ b_m &= \frac{1}{p}\sum_{k=0}^{p-1} y_{pm+k}. \end{aligned} \tag{1}$$

Where $G_{n,m}$ represents the graphical Braille dots grid computed over the dimension 16 x 16 dots. This functions are dependent from camera settings. E.g. for evaluation set vertical resolution of the camera was set to 256 pixels and vertical resolution was 1600 pixels. The n and m represent the dot number for X and Y axis. A dot value for pixels around a grid point is computed as an average value over all evaluated pixels which are located in acceptable distance to the grid point. For one grid point in our evaluation case we regard $p = 16$ neighbouring values $p/2$ to the left and to the right $p/2$ from the current value for X and Y axes. The set $G_{n,m}$ is dependent on a_n and b_m functions.

Equation Equation 2 calculates dot values.

$$\begin{aligned} S_{n,m} &= \sum_{n,m} \delta_{n,m} \cdot d(P_{n,m}, G_{n,m}) \qquad (2) \\ \delta_{n,m} &= \begin{cases} 1 & \text{if } d(P_{n,m}, G_{n,m}) < d_{max}, \\ 0 & \text{else.} \end{cases} \\ d(P_{n,m}, G_{n,m}) &= \sqrt{(G_x - P_x)^2 + (G_y - P_y)^2}. \end{aligned}$$

Where $S_{n,m}$ represents the value of matching detected pixels $P_{n,m}$ with coordinates P_x and P_y computed over the dimensions n and m around correspondent grid point $G_{n,m}$ with coordinates G_x and G_y. d represents the distance between a grid point and an evaluated current pixel point coordinates. d_{max} is a threshold value for decision between black (0) and white (255) colour e.g. 127. $\delta_{n,m}$ is a coefficient with value 1 for pixel range $< d_{max}$ or 0 otherwise.

Therefore presentation appropriated for Braille user can be calculated using this method and is shown in Figure 7 for triangle and in Figure 8 for circle.

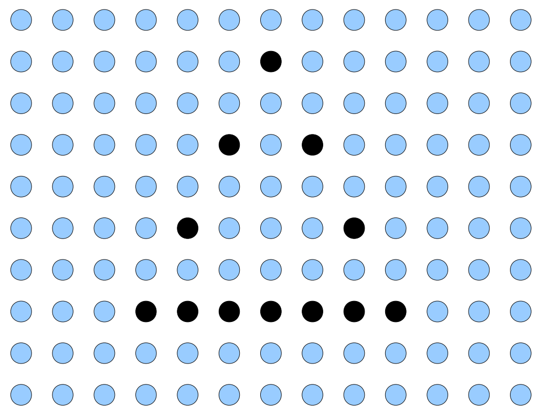

Figure 7: A triangle demonstration for Braille user.

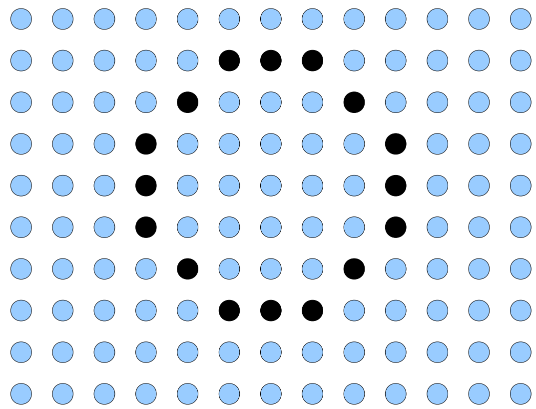

Figure 8: A circle demonstration for Braille user.

5 CONCLUSIONS

We have presented a system for Braille learning support using the smart camera 360SCAN. Learning support for visually impaired people is required for specific information presentation, which in turn relies on standard Braille output device and automatically processing of bio-inspired smart camera images in a natural environment. In order to provide education support, we apply image processing on recorded images and object recognition to the smart camera output. The edge detection methods enhances object recognition by providing accurate object shapes of real-live objects and makes this system unique for object presentation to visually impaired people.

The main contribution of described work is a system including a smart camera, a Braille module and an image processing algorithm implementation that provides methods for shape detection of real-live figures and supports automatic information presentation. Another contribution of the proposed method is that image edges can be transformed to the presentation on Braille display also directly without any image processing. It is possible due to bio-inspired construction of camera sensor. Additional contribution is that our approach provides Braille users with images recorded from natural scenes. This approach makes use of the modern image processing libraries. We employ state-of-the-art features extraction and clustering methods. We conducted several experiments that evaluate the methods we have implemented and demonstrate learning figures captured by the smart camera presented in form of taxels. The experimental evaluation presented in this paper demonstrates the effectiveness of employing the image processing techniques for an education system.

As future work we plan to produce our own Braille display in order to use it as an output device for 360SCAN camera. We plan to extend an automatic education approach of image analysis to new application scenarios also involving information storage and digital preservation. The educational use cases could be extended with specific software for visually impaired people in order to give a method at hand to work with figures and images.

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Handling Procrastination in Mobile Learning Environment
Proposal of Reminder Application for Mobile Devices

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Keywords: Mobile Learning, e-Learning, Procrastination, Forming of Habit.

Abstract: This paper deals with the issue of procrastination in e-learning. Suggested approach is based on compensating e-learning shortcomings and applying principles of forming a habit. Technical implementation is possible through use of mobile devices, incorporated in e-learning strategy. Respective habit loop would consist of immediate trigger (delivered by a reminder application), desired behavior (engagement in learning session) and immediate reward. Requirements on learning strategy, software and hardware are discussed, as well as a reminder mechanism and relevant system of rewards. Data processing in the reminder application is outlined for computing initial settings of the application.

1 INTRODUCTION

Procrastination is known as a tendency to delay performance of important tasks, followed by feeling of distress (Solomon and Rothblum, 1984). This phenomenon is commonly found in the academic domain and there are many studies focused especially on undergraduate and graduate students. It was proven that many students procrastinate in relation to academic activities (Steel, 2007). This can be significant issue in e-learning, as e-learning courses tend to be mostly organized by student himself. Procrastination in e-learning courses can also emerge because online learning tasks can quickly overwhelm students, as well as existence of too much data and information to read and to respond to (Roberts, 2003). Procrastination not only causes discomfort or anxiety but also often results in unsatisfactory performance (Solomon and Rothblum, 1984).

M-learning or mobile learning brings many opportunities for learning and e-learning as well. Smart phones, tablets and other devices can be used for enhancing learning experience for students and teachers as well, therefore increase productivity and learning results (Dittmar, 2013). Opportunities offered by these mobile devices can be roughly defined as:

- opportunity in the sense of mobility - it is possible to bring the device along all the time
- opportunity in immediate use, trigger and response - it is possible to use the device anytime, the device can react according to its pre-set functions without previous interaction and user can respond immediately
- opportunity in form of a new platform for applications - for smart phones, tablets and other mobile devices with Android, iPhone and other operating systems
- opportunity in usage of current location - limited use for learning

Mobile learning as well as traditional web-based e-learning suffers from absence of face-to-face communication between teacher and student, and also communication between students themselves. Generally, e-learning in its online form lacks face-to-face educational experience (Garrison et al., 2003). Another issue of m-learning is the fact, that learners can be more easily distracted in mobile environment (Joo et al., 2013). Both e-learning and mobile learning allows for managing learning process solely by student, therefore increasing risk of procrastination.

This paper explores a possibility of handling procrastination in e-learning with use of mobile devices.

2 PROPOSED APPROACH

Approach which is suggested in this paper for dealing with procrastination is based on compensating e-learning shortcomings and applying principles of forming a habit. Technical implementation is possible through use of mobile devices, incorporated in e-learning strategy. Such mobile learning would use advantage of both mobility of the device and custom application linked with existing e-learning system as well.

2.1 Need for a Reminder System

Challenges and opportunities, regarding responsibility and control in teaching and learning, are different from traditional learning. Crucial step in ensuring successful outcome in e-learning is having a learner accept responsibility for one´s learning, in both knowledge aspect and cognitive abilities which are needed for continuous learning (Garrison et al., 2003). Continuous or routine learning is more difficult for learner to maintain than in traditional learning, because there are no reminders in traditional face-to-face learning sessions. With no reminders (only e.g. deadlines in online e-learning platform, which has to be accessed first in order to reveal this reminder), students can easily put learning aside and engage in other activities, therefore suffer from procrastination. The opportunity of more effective reminder system lies in usage of mobile devices, which will be discussed further in section 3.4 Reminder Mechanism.

2.2 Forming a Habit

The ultimate goal of implementing a reminder application into e-learning strategy should be creation of a habit. With self-controlled learning such as e-learning, the amount and distribution of time dedicated to learning is usually not fixed and is likely to be postponed continuously, ending in procrastination. Solution to this problem can be creation of a habit loop, with help of reminder application. Duhigg specifies that we can create new neurological routines and therefore a new pattern, which will become automatic behavior. Forming a habit loop involves three phases (Duhigg, 2012):

- trigger / cue - this is to be delivered by the reminder application
- habit / routine - desired behavior (in this case generally participation in learning)
- reward - important is that a reward must be immediate after fulfilled learning session

This principle is similar to incentives and rewards in social computing, on workplaces and other areas. Reminders through mobile device would serve as immediate incentive, followed by a small but also immediate reward, e.g. gain of points towards a final score. The immediate nature would solve problem that effort level always drops following an evaluation if the agent views the time until the next evaluation as too long (Scekic et al., 2013). Figure 1 depicts suggested sequence of actions for habit loop in e- learning.

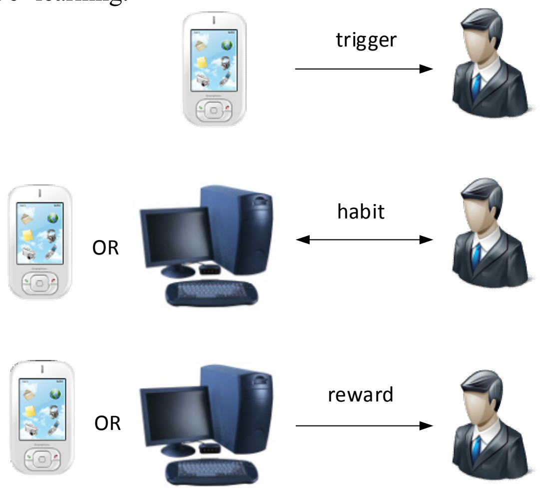

Figure 1: Suggested habit loop for e- learning with use of a mobile device as a reminder.

2.3 Adjusting e-Learning Strategy

There are three components of e-learning - enabling technology, learning content and learning design. Good e-learning is then a combination of technology that works, meaningful content and effective learning design (Fee, 2009). Incorporating reminder system into e-learning strategy would:

- pertain into learning design
- be conditioned by learning content
- take an advantage of mobile technology

Integration into learning design would require careful planning regarding time management, estimated difficulty of learning sections and system of rewards. It would be conditioned by amount, diversity and structure of learning content. The organization of content could be inappropriate for immediate implementation of reminder system and could need restructuring. Mobile technology is a requirement for successful interference into learner´s awareness without need of entering online course or even without internet connection. This is an advantage of application for mobile devices in comparison with web-based application.

3 OVERVIEW OF CONDITIONS

This section includes overview of basic conditions, which are necessary for implementing mobile reminder system to e-learning course. The reminder application is primarily aimed at learners, with a goal to engage them in learning process, but can also be modified for active usage by instructors, e.g. for inspiring them to continuous improvement of learning content. Basic scenario discussed in this article is concerned with only learners as users.

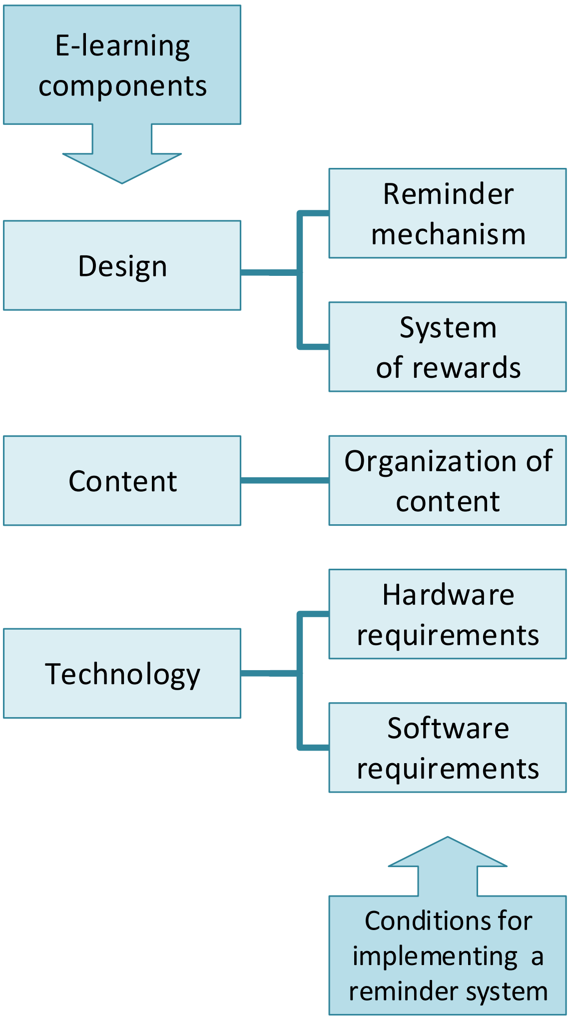

Figure 2: Requirements for implementing mobile reminder system in relation to three components of e-learning.

3.1 Hardware Requirements

In order to use advantage of mobile device, student has to own such device. This should be less and less pressing issue, as an adoption of mobile devices such as smart phones or tablets increases. In year 2011 was surveyed that 35 percent of Americans own a smart phone (Pew Internet & American Life Project, 2011). However, implementation of reminder system into e-learning still has to be unobtrusive. The student must be able to perform the course without reminder application and rewards, which should be compensated in other form. Web-based reminder system could be proxy for mobile reminder system in a case of its absence.

3.2 Software Requirements

New software is needed for implementing mobile reminder system into e-learning design. Android and iOS applications for mobile devices are not compatible, therefore two version of the same application should be created, one for Android platform and other for iPhone. The application should cooperate with existing e-learning system / platform / portal, so it can gather and update required information for correct functionality of mobile reminder application.

The application should be able to use this data along with custom data added by user, in order to manage its user´s schedule of learning sessions and provide suitable reminders. These reminders should be both visual and audible on mobile device.

In order to connect reminder application to particular user´s account in e-learning system, a connection needs to be established. Parameters of this connection should arise from implementation details, user should be prompted to provide these parameters and of course security issues need to be taken care of. Transfer of data from e-learning system to reminder application could proceed by wireless network without user´s intervention.

3.3 Organization of Content

The course organization should be adapted for use by the reminder system. Ideally, proportional distribution of learning content should be ensured. This includes especially:

- consistent form of individual learning sections
- approximately equal estimated time required for individual learning sections
- approximately equal difficulty of individual learning sections

Proportional distribution of learning content should provide for equally distributed rewards and also easier evaluation of learners. More importantly, structuring learning content into equal sections makes planning of learning process much easier. This arrangement also justifies usage of reminder mechanism. This is because equally time-demanding and effort-demanding sections can be included into schedule as the same activity and can create a habit.

3.4 The Reminder Mechanism

Reminder should be activated according to preferred initial schedule settings. If user does not enter learning course in defined time interval, reminder should be activated repeatedly. There should be also possibility for user to deactivate repeating reminder, but only if he provides alternative time for it. In this action the learner creates a commitment, which he should try to fulfill.

Initial settings of reminder application would be defined by user, allowing for user´s individual time schedule. Furthermore, reminder application should be able to analyze user data concerning time schedule, which are expected to be developing continuously, and adapt its reminders appropriately. Adaptation can be carried out in reaction to start of previous learning session. As previous appropriate learning session can be taken:

- learning session performed on previous day
- learning session performed on previous working day (in working days) or weekend (on weekends)
- learning session on previous day of the week

Preference of individual methods is dependent on existing weekly schedule of learner, and therefore should be part of initial settings. More complex algorithm is also possible, which would decide most suitable method on the basis of continuous development regarding starts of sessions.

There should be also mechanism for deciding successful fulfillment of learning session, and deactivating current reminder. Frequency of reminders is expected to be on daily basis, but could be also adjusted in initial settings or automatically generated based on previous successfully performed learning sessions.

3.5 System of Rewards

System of rewards refers to the third phase of habit loop. Rewards have to be immediate and satisfying. Immediate rewards are usually much simpler to implement in online environment than in traditional environment. When learner interacts with e-learning course, he can get immediate response from server, based on performed activities. If learner accomplishes desirable activity, e-learning system can immediately deliver reward.

While implementing reminder application, reminder should lead to desirable activity, and this activity should result in appropriate reward delivered to learner. This activity can be specified by:

- generally amount of time actively spent in learning session (technique for measuring activity must be further specified)
- fulfilling a daily quota, specified by learner earlier (technique for measuring activity must be further specified)
- completed learning section or tasks (conditions for completion must be specified)
- accomplishing required learning sessions and tasks before defined deadline

Immediate rewards can have various forms, e.g.:

- gain of points towards a final score, which has influence on learner´s evaluation
- accomplishment badges, which can be visible to other participants of the course, therefore supporting competition

If learning content is proportionally distributed among learning sessions and appropriately designed and structuralized, rewards can be also proportional and expectations therefore stable. This consistency also contributes to creation of a habit.

4 DATA PROCESSING

Several ideas from previous section will be explored in greater depth here, regarding especially data and its processing. This relates also to communication with e-learning system and gathering data from learner in the reminder application.

4.1 Data from an e-Learning System

The mobile reminder application should be able to gather data from relevant e-learning system in order to function properly. This data includes:

- currently enrolled e-learning courses
- available learning sections (and subsections) in each course
- estimated required time for individual learning sections (and subsections)
- deadlines scheduled by e-learning system

The list contains only essential components and can be further developed in case of extended cooperation of the application and e-learning system.

4.2 Data Obtained from User

In order to adapt the reminder application to individual time schedule of learners, another set of data is needed from learner. Learner is a sole user of this application in context of this paper. This data are to be obtained in the mobile application settings. Learner should be prompted to provide this data before using the application. This data can include:

- preferred time of the day for the reminder (can be same for every day, different for working days and weekends, or different for every day)
- enabling only particular days of the week for reminders, therefore establishing expected frequency for learning sessions
- possibility of dividing daily learning session into more parts (and reminders)
- preferred time quota for learning per day / week, in other words length of daily / weekly session, in single number or range
- custom deadlines defined by learner

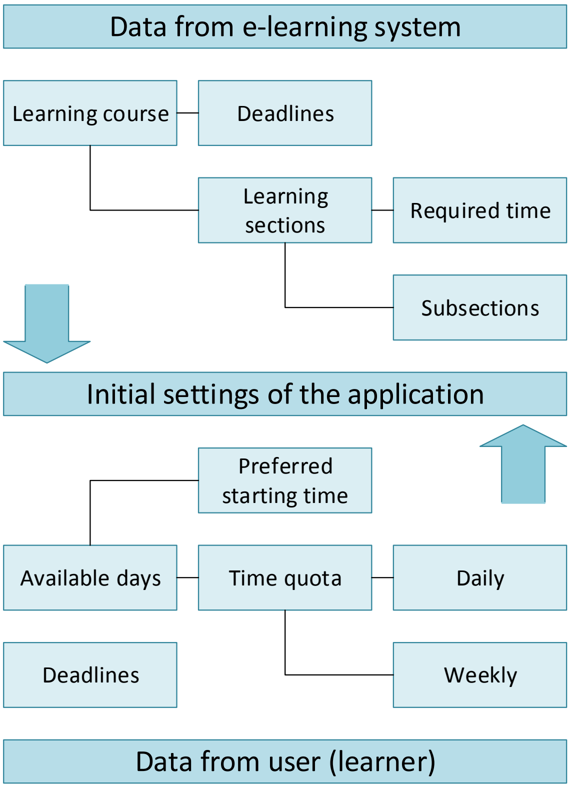

Figure 3: Initial settings of the application.

4.3 Initial Settings of the Application

Data acquired automatically from e-learning system and manually from learner should form initial settings of the reminder application. The application should have then implemented algorithms for suggesting individual learning plan with relevant distribution of reminders. Based on available data, learner could choose between different learning plans with relevant algorithms.

These learning plans can be changed or adjusted later either automatically or customized by user. Automatically e.g. in case of diversion from expected values in time spent in learning sessions or in case of change in available learning days. Customized e.g. by choosing another algorithm or inserting a new deadline. Two types of learning plans are proposed as an example.

4.3.1 Minimum Quota with Deadline

This learning plan is based on proportional distribution of learning sessions in every day available till deadline. Proportional implies that approximately the same amount of learning content should be covered in every day. Every day available means every day enabled by learner for learning sessions. Deadline can be official from e-learning system or custom defined by learner. Required values for this plan are: number of learning session and their estimated required time, days available for learning and deadline (official or custom).

4.3.2 Maximum Quota in Minimum Time

This learning plan is suitable for quick learning - for covering the most material in minimum time possible. Required values for computing this plan are: number of learning session and their estimated required time, days available for learning and defined quota for learning per day and per week.

4.4 Runtime Adaptation

At starting the learning session and at ending the session, feedback should be sent to the reminder application from e-learning system. This way, the reminder application can be up-to-date and deliver accurate performance. Information about starting the session would deactivate current reminder and information about ending it would allow computing data about session length and fulfilled learning sections. Information about performed learning would continuously update distribution of learning sessions and also reminders in the learning plan.

More sophisticated version of the mobile reminder application could also recommend alteration of the learning plan. This can be done according to development of learning sessions, preferred starting time of sessions and usual duration of sessions. The application then needs to store user data about past sessions. With data storage and appropriate functions, more complex analyses can be made, which would help learner to distribute reminders more fittingly into one´s schedule.

5 CONCLUSIONS

This paper presented idea of the mobile reminder application for dealing with procrastination in e-learning. Underlying principle for implementing the mobile reminder application was the principle of habit loop, which was chosen as an ideal instrument for dealing with long-term procrastination.

Presented application of habit loop is possible due to pervasiveness of mobile devices and its immediate possibility of interaction. Ideas and possibilities were discussed in relation to this approach. Fundamental requirements were outlined and substantial part of this section was devoted to reminder mechanism and system of rewards. The paper also considers basic schema of data processing in the application. Implementation details were not covered in this article, this will be subject of future studies, as well as refinement of suggested ideas.

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CG Teaching Material for the Electronic Laboratory Textbook
Esterification of Acetic Acid and Ethanol

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Keywords: Teaching Material, Visualization, Electrostatic Potential, Quantum Chemical Calculation.

Abstract: CG animation of the esterification of acetic acid and ethyl alcohol was made based on quantum chemical calculations by use of MOPAC with PM5 Hamiltonian. The CG animation could simultaneously display realistic shapes and electrostatic potentials of the intermediates of the reactants on the way of the reaction profile besides the ball-and-stick model of the intermediates. A survey of five chemistry textbooks used in Japanese high school revealed that molecular models in chemistry were illustrated by popular molecular models such as ball-and-stick, space filling, and free-hand. There were only a few examples illustrated by the models with characteristics of molecules for chemical reaction mechanism. The CG animation could demonstrate these images of dynamical reaction mechanism for the esterification and can be loaded with tablet PC and smart phone. We are trying to produce an electronic laboratory textbook of the esterification in which the CG teaching material is combined with chemical experiments of student's laboratory.

1 INTRODUCTION

Chemical education has the circumstances performed through an experiment. Understanding the observed phenomena, chemists use to imagine and explain observations in terms of molecules. Observed phenomena and molecular level models are then represented in terms of mathematics and chemical equation (Gilbert, 2009 and Tasker, 2010). Student's difficulties and misconceptions in chemistry are from inadequate or inaccurate models at the molecular level (Kleinman, 1987). Visualization is great help for students to have images in the molecular level. It is our aim to produce computer graphics (CG) teaching material based on quantum chemical calculations, which provides realizable images of the nature of chemical reaction (Ikuo, 2006 and 2009). If the CG teaching material is combined with chemical experiments of student's laboratory, students would observe the reaction from three thinking levels, namely, phenomena in the observable level and CG teaching material in the molecular level, and chemical equation in the symbolic level. Our ultimate goal is to produce an electronic laboratory textbook, which integrates these three levels.

Chemical reaction is generally expressed by a chemical formula that provides information of the reaction about its stoichiometry; however, chemical formula does not provide information about its realistic shape and reactivity of molecule. This information is essential to realize images of chemical reaction. Molecular models such as wire, ball-and-stick, and space filling, are popularly used to realize images of molecule. They are used properly for the purpose of getting information of molecule about bond length and its angle, shape, and so on. Generally, electron density iso-surface on CG is displayed with realistic shape of molecule, and electrostatic potential on CG provides information about electrical character of a certain part of molecule.

In this paper, we report here a CG teaching material adopting the CG with electrostatic potential on electron density that represents both of realistic shape and electrostatic potential of molecule for the purpose of making electronic laboratory textbook of the esterification, which integrates the observable level experiment and the molecular world, along with a survey of five chemistry textbooks used in Japanese high school about molecular models in chemistry.

2 PROCEDURE

2.1 Quantum Chemical Calculation

Structures of intermediates on the esterification of acetic acid and ethyl alcohol and their electrostatic potentials on electron density were calculated as follows: the semi-empirical molecular orbital calculation s MOPAC (Stewart, 1989) with PM5 Hamiltonian in CAChe Work System for Windows (Former name of Scigress, ver. 6.01, FUJITSU, Inc.) was used in all of calculations for optimization of geometry by the Eigenvector Following method, for search of transition state by use of the program with Saddle point Search, and for search of the reaction path from the reactants to the products *via* the transition state by the intrinsic reaction coordinate (IRC) calculation (Fukui, 1970). Details of procedure of the quantum chemical calculations were described in the previous paper (Ikuo, 2006). The electrostatic potential on electron density (EPED) (Kahn, 1986) was calculated based on structures from the results of the IRC calculation.

2.2 CG Teaching Material

A movie of the reaction path was produced by the software DIRECTOR (ver. 8.5.1J, Macromedia, Inc.) following the display of the bond order of the structure of the reactants in each reaction stage, which was drawn by the CAChe. The obtained CG of EPED model was combined with those of ball-and-stick model and reaction profile in the same reaction stage. It was confirmed that the drawn CGs of the molecular models of reactants moves smoothly. The red ball, which indicates progress of the reaction, was arranged on the reaction profile and simultaneous movements of the ball and the reactants were confirmed. The movie file was converted to the Quick Time movie by the Quick Time PRO (ver. 7.66, Apple, Inc.) and was saved to iPad (Apple, Inc.) by using the iTunes (ver. 10.7, Apple, Inc.).

2.3 Survey of High School Textbooks

Survey of five chemistry textbooks of "Chemistry I, II" used in Japanese high school (Textbooks of "Chemistry I" and "Chemistry II" in Japanese high school, 2003 and 2004) was conducted to investigate how the molecular models were used in chemistry in the actual circumstances.

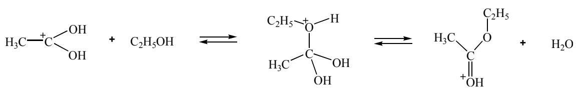
3 RESULTS AND DISCUSSION

3.1 Reaction Mechanism

Esterification of acetic acid and ethyl alcohol is described as shown in the equation (1).

$$CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O \quad (1)$$

The mechanism of the reaction is well known (For example Loudon, 1984), and generally, the esterification proceeds in the presence of proton catalyst. The rate-determining step includes the paths of an attack of the oxygen atom of hydroxyl group of ethyl alcohol to the central carbon of the formed carbonium ion and release of water as shown in the Scheme 1. This step dominates all over the reaction, and then the calculation based on quantum chemistry on the rate-determining step was carried out. Although another mechanism that involves more than a pair of reactants is possible as reported in the case of carbonic acid formation (Nguyen, 1984), it was not considered in this paper for simplicity of program.



Scheme 1: Mechanism of the esterification on the rate-determining step.

3.2 Optimization of the States of Reactants and Products on the Rate-determining Step

Appropriate geometry of reactants was calculated by the Eigenvector Following method in MOPAC. The calculation was carried out until the cut off value of less than 1 in root mean square (RMS) gradient. The calculation of optimization of the reactants was started from a certain state where reactants of acetic acid and ethyl alcohol with specific interactions. Tentative heat of formation, ΔH_f, was obtained by MOPAC calculation. ΔH_f s of the states of reactants and products are shown in the Table 1.

The ΔH_f value of the state of reactants was decreased from 262.6089 to 84.23436 kJ mol^{-1} after 40 cycles of geometry optimization with value of 0.96023 in RMS gradient. The value of RMS indicates that the calculation was converged. Therefore, calculated geometry of the reactants can be considered as the lowest in energy in the present calculation condition. Similarly, the calculation of the state of products was started from a certain state where the carbonium ion and water with specific interactions. The $\Delta\ H_f$ value of the state was decreased from 891.7311 to 311.7951 kJ mol^{-1} after 87 cycles of geometry optimization with value of 0.67331 in RMS gradient. The value of RMS indicates that the calculation was also converged. Geometries of both the reactants and the products in the lowest energy were determined by these optimizations.

Table 1: Optimization of the states of reactants and products on the rate-determining step.

State	ΔH_f^{a} / kJ mol^{-1}		RMS gradient	Number of cycles
	Before optimization	After optimization		
Reactants[b]	262.6089	84.23436	0.96023	40
Products[c]	891.7311	311.7951	0.67331	87

[a] Tentative heat of formation ΔH_f was defined by MOPAC. Calculation was started from a certain state.
[b] Acetic acid and ethyl alcohol with specific interactions.
[c] The carbonium ion and water with specific interactions.

3.3 Determination of Transition State on Reaction Path of Rate-determining Step

Geometry of the intermediate in the transition state was searched by use of the program with the saddle point search in MOPAC. The optimized geometries of the reactants and the products mentioned in the above section were used with the data of starting files for the saddle point search. Through the calculation, reasonable structure of intermediate in the transition state was obtained. The structure was further refined by program refine transition state in MOPAC.

The vibrational analysis of the intermediate was performed by use of the program FORCE in MOPAC. A single absorption peak in the negative region was found at *ca*. -1200 cm^{-1}. The result indicates vibrational mode due to the decrease of potential energy for the direction of only one path via a true transition state at the saddle point. The structure of intermediate obtained by MOPAC was almost identical to that calculated by Gaussian 03W at 6-31G(d) level. These mean a positive verification of optimized structure of the intermediate in the transition state.

The reaction path from the reactants to the products *via* the transition state was searched by the IRC calculation in MOPAC with the data files of the obtained intermediate of the transition state, and the files of the reactants and products as obtained in section 3.2. After the calculation, each reaction path from the transition state to the state of the reactants or reaction path from the transition state to the state of the products was searched individually where 1963 steps or 1046 steps were contained. Total number of 3010 steps means the same number of geometries of intermediates on all over the reaction path.

3.4 Atom Coordinates of the Intermediate

The atom-coordinates of the intermediate in transition state were extracted from the results of the IRC calculation in the above section. The Figure 1 shows them on three-dimensional coordinates, in which sphere size of atoms is proportional to atomic radius. The best angle of bird's-eye view on CG was selected to show all atoms composed in the intermediate.

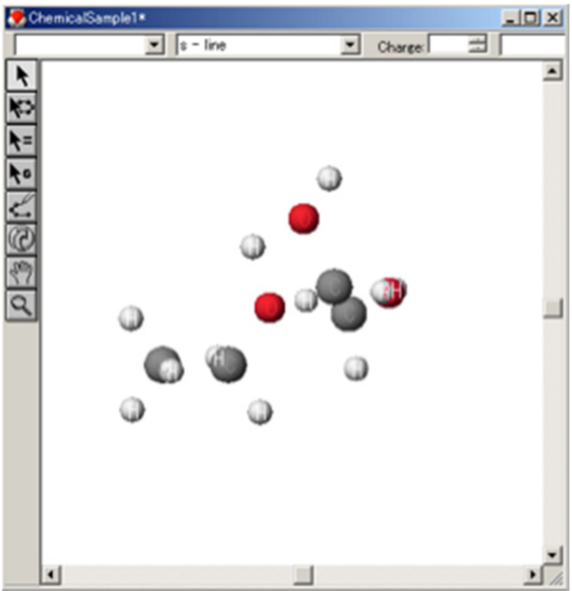


Figure 1: Geometry of atoms in the transition state.
: oxygen, : carbon, : hydrogen

3.5 Iso-surface of Electron Density in the Transition State

An iso-surface of the electron density of the intermediate was calculated based on the coordinates of atoms mentioned in the above section and were shown in the Figure 2. The coordinates of atoms were converted to the iso-surface by this procedure. The iso-surface of the electron density at the value of 0.01 eÅ^{-3} was illustrated with the mesh pattern. The iso-surface demonstrates realistic shape of the intermediate.

3.6 Electrostatic Potential in the Transition State

The electrostatic potential (Kahn, 1986) was calculated based on the coordinates of atoms mentioned in section 3.4 and superimposed on to the iso-surface as shown in the Figure 3. The values of electrostatic potentials were represented in different colour on the model of intermediate in the transition state, and figure legend of colour boundaries for electrostatic potential was also listed. Distribution of the electrostatic potential among the intermediate can be seen by the colours. For example, oxygen of ethanol is negatively charged with relative value of -0.06 based on evaluation of energy of interactions of prove proton to the charge of iso-surface, and hydrogen of carbonium ion is positively charged with relative value of +0.09. The model by electrostatic potential provides information about electrostatic distribution of the intermediate on the way of the reaction.

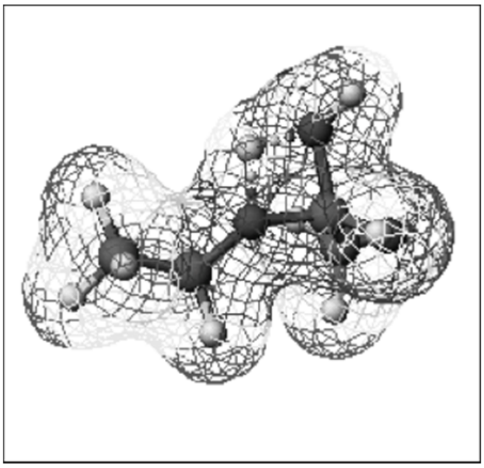


Figure 2: Iso-surface of electron density besides the ball-and-stick model in the transition state. Net represents iso-surface of electron density with 0.01 $eÅ^{-3}$

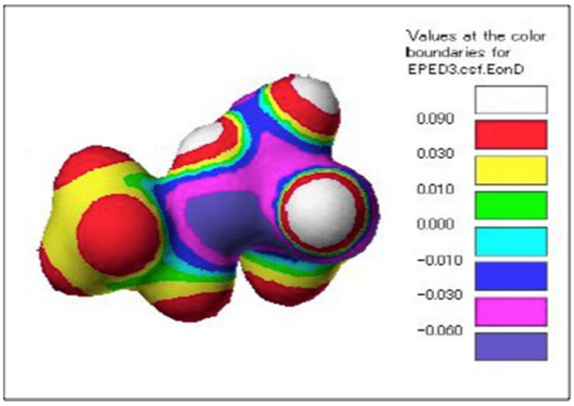


Figure 3: Electrostatic potential on electron density in the transition state.

3.7 Combination of the Electrostatic Potential Map, the Ball-and-stick Model, and the Reaction Profile on CG

The CGs of the EPED model mentioned in the above section, ball-and-stick model, which have been reported previously (Ikuo, 2006), and reaction profile on the same state were combined, and the obtained combination CG is shown in the Figure 4. The EPED model displays distribution of electrostatic potential on the surface of the intermediate with realistic shape, and the ball-and-stick model shows skeletal structure of the intermediate. The reaction profile demonstrates the degree of the reaction progress by the ball illustrated in the figure. The combination CG is able to provide information about electrostatic potential and structure of intermediate of molecule in a certain state simultaneously.

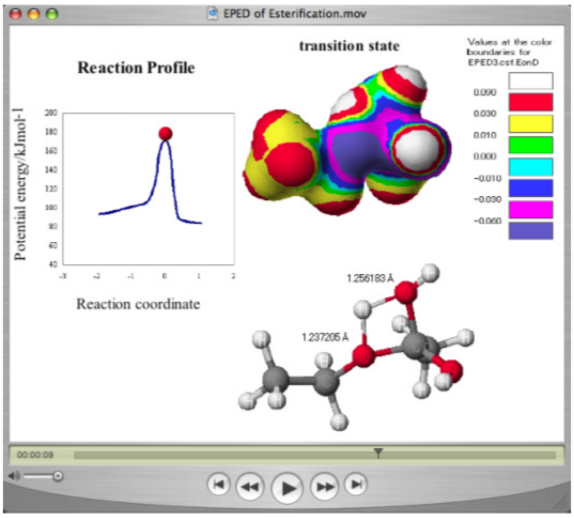


Figure 4: Combination CG of electrostatic potential map, ball-and-stick model, and reaction profile.

3.8 CG Teaching Material

The Quick Time movie file was created as teaching material by use of 100 frames of combination CGs. The Figure 5 shows five frames of representatives of the combination CGs on the way from the state of reactants to that of products *via* the transition state. The teaching material demonstrates the changes of electrostatic potential and realistic shape of the intermediate of the reaction on the reaction profile in all stages at the same time. The ball on the reaction profile can move by users' choice of the way of automatic movement or manual movement along the reaction coordinate, which indicates the most probable pathway of chemical reaction according to the IRC theory (Fukui, 1970). Other CGs such as EPED and ball-and stick modes are synchronized with the movement of the ball on the reaction profile by use of the Quick Time control bar so that the degree of the reaction progress and structural change of the molecules of all stages could be demonstrated simultaneously. The animation provides details of the chemical reaction mechanism dynamically. The CG teaching material can be loaded with tablet PC, and smart phone such as iPad and iPhone.

3.9 Survey of Textbooks

Since, it is usually the last chance for most of citizen to deal with molecular models, survey of five different textbooks each from "Chemistry I" and "Chemistry II" used in Japanese high school (Textbooks of "Chemistry I" and "Chemistry II" in Japanese high school, 2003 and 2004) was conducted to investigate how the molecular models were used in chemistry in the actual circumstances. Frequency of the use for representation of molecules by general molecular models is summarized in the Table 2.

Molecular models were illustrated by popular molecular models such as ball-and-stick, space filling, and free hand. A small number of molecular models were adopted to express polarity of molecule with a notation of δ^- or δ^+. Models expressing interactions of molecules such as hydrogen bond were found in some books. Models giving information about pseudo-reaction mechanism were found in two textbooks. These results reveal that there were only a few examples illustrated by the models with realistic shapes and characteristics of molecules for chemical reaction mechanism.

The survey implies that the proposed CG animation is significantly effective to realize images of the reaction mechanism for chemical reaction, *i.e.* the CG animation adopting the CG with electrostatic potential on electron density that can represent both of realistic shape and electrostatic potential of molecule. The CG animation would lead student to realize images of dynamical reaction mechanism for the reaction.

Integration of the present CG teaching material and laboratory textbook would serve as bridge between the observable level experiment and the molecular world.

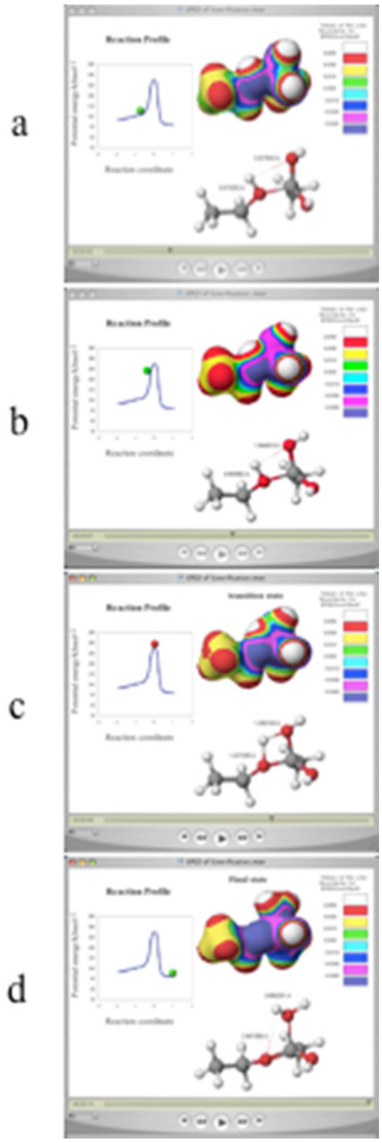


Figure 5: CG Teaching Material.

Table 2: Frequency of the use for representation of molecules by popular molecular models in high school chemistry textbooks.

Representation of molecules	Types of molecular models: Wire <Dreiding-like>	Ball-and-stick <HGS-like>	Space filling <Stuart-like>	Free-hand illustration
Structure	◎	◎	◎	◎
Polarity of molecule	–	○	○	○
Interactions of molecules	–	○	○	○
Reaction mechanism	–	–	△	△
Electrostatic potential	–	–	–	–

* Five Chemistry textbooks of "Chemistry I, II" in Japanese high school [7].
◎: used frequently in all textbooks; ○: used sometimes in all textboks;
△: used once in two textbooks; –: not used in any textbooks.

4 CONCLUSIONS

The CG animation of esterification of acetic acid and ethyl alcohol could simultaneously display realistic shapes and electrostatic potentials of the intermediates on the way of the reaction profile besides the ball-and-stick model of the intermediates. A survey of five chemistry textbooks used in Japanese high school revealed that molecular models were illustrated by ball-and-stick, space filling, and free-hand, and there were only a few examples illustrated by the models with characteristics of molecules for chemical reaction mechanism. The proposed CG animation could demonstrate these realistic shapes and characteristics of molecules. The CG teaching material can be loaded with tablet PC, and smart phone such as iPad and iPhone. Now we are trying to produce an electronic laboratory textbook of the esterification in which the CG teaching material is combined with chemical experiments of student's laboratory.

ACKNOWLEDGEMENTS

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Textbooks of "Chemistry I" and "Chemistry II" in Japanese high school: Daiichigakusyusya, 2003 and 2004; Jikkyosyuppan, 2003 and 2004; Keirinkan, 2002 and 2003; Sanseido, 2003 and 2004; Tokyosyoseki, 2003 and 2004. (In Japanese) Textbooks were listed in alphabetical order.

Mobile Learning for COOL Informatics
Cooperative Open Learning in a Vocational High School

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Keywords: Mobile Learning, Cooperative Open Learning.

Abstract: COOL Informatics is a project that wants to foster informatics education in primary and secondary schools by integrating it in different subjects. The term "COOL" references to the following approaches: (1) to the Austrian teaching model COOL – COoperative Open Learning, (2) to COmputer-supported Open Learning as well as (3) to the adjective "cool" in the sense of motivating and useful. Mobile Learning with mobile phones and tablets is one parte of COOL Informatics as it covers all three approaches. From our experiences and the results of former discussions with students we can say, that technology-supported learning seems to be more motivating and "cool" than traditional learning methods. This is one reason why we introduced mobile learning in our vocational high school of commerce and tourism. The paper describes the steps of the implementation from workshops for the students over mobile learning in language lessons to app programming in Applied Informatics for cross-curricular learning. Finally it reports on the evaluation of the workshops and the project on app programming.

1 INTRODUCTION

Students are „digital natives". They grow up with technology and they use it in their everyday life. Lundin et al. (2010) mention that "Mobile IT is becoming one of the most commonly used tools in our everyday live." So why not use mobile phones and other mobile devices in classrooms? Especially mobile phones play an important role in the students' life and most of them don't even turn them off in the classroom. Although this is a nuisance, as some teachers may reply, it could also be a very useful resource and have benefits for learners as well as for teachers (Corbeil and Valdes-Corbeil, 2007; Traxler, 2007).

Especially for language learning, mobile devices offer plenty of possibilities and may be inte¬grated in the classroom as well as in informal learning settings. (Chinnery, 2006; Sabitzer and Bischof, 2012)

This paper reports on the introduction of mobile learning as a part of the project "COOL Informatics" in an Austrian vocational school of commerce and tourism with students between 14 and 19 years.

It describes the introductory workshops for students and two approaches to mobile learning: the use of smartphones and tablets in foreign language lessons and the project "App-Programming with the App-Inventor" in Applied Informatics. Finally, the evaluation and outcomes of questionnaires given before and after the workshops are presented as well.

2 MOBILE LEARNING AND COOL INFORMATICS

COOL Informatics can be interpreted in different ways as proposed in (Sabitzer and Pasterk, 2013). All of the three interpretations want to improve the learning process by considering how the brain works in educational context.

- COOL as "cool" describes learning situations in a sense of interesting or fun. One advantage of such situations can be that the neurotransmitter dopamine is released. That happens when for instance people are curious or have fun and dopamine supports learning and memory functions (Wise, 2004). Learning by playing would be an example for this interpretation.
- COOL as COoperative Open Learning (Hölbling, Wittwer & Neuhauser, 2011) means an approach to handle the heterogeneity in classrooms and to promote soft-skills like communication competence or responsibility. It bases on

concepts from progressive education and emphasizes on cooperative aspects of learning. They support the longtime memory because the required recalls from memory during the cooperation lead to a re-storage and hence better storage (Brand and Markowitsch, 2009).

- COOL as COmputer-supported Open Learning means to support and improve cooperation in education by the usage of technology. The modality or multimedia effect is a further advantage of computer- or technology-supported learning. It means that information is better stored and recalled, if it was double-coded and students perceived it through differrent media, like e.g. visual and auditory media (Low & Sweller 2005).

Mobile learning can be included in all of these three senses as a supporting and motivating device.

- For a lot of students Mobile learning is “cool” because they can use their own devices for learning.
- To improve Cooperative Open Learning mobile devices would be perfect because of the many different tools for communication and collaboration technology provides. Students can call each other, send messages and E-Mails or work together on one file at the same time but different locations.
- Mobile learning can today be seen as variation of Computer-supported Open Learning because most smartphones and tablet-PCs are very powerful and have similar functionalities like a PC or a notebook. Of course the mobile devices cannot replace PCs but they can be used to support learning by e.g. applying different media from the Internet.

3 IMPLEMENTING MOBILE LEARNING

The introduction of mobile learning in the vocational high school of commerce and tourism in St. Veit was accomplished in three steps and three subjects:

- A mobile learning workshop for students was offered in the voluntary subject “Learning to learn”.
- The use of mobile devices in COOL Spanish and Russian lessons was boosted.
- A creative school project on app programming was accomplished in Applied Informatics. It was funded by a regional program of the Austrian teaching support system IMST: “Teaching Informatics creatively”.

3.1 School and Participants

The Vocational High School of Commerce and Tourism in St. Veit was chosen, because it offers education in subjects that are a good basis for COOL: “Applied information technology” and “Learning to learn”.

The school offers different branches of education, one branch for three years and two branches that lead to the qualification for university entrance (A-levels): Eco-Business (Environmental Studies) and International Management with three foreign languages (English, French, Italian), some classes with English as working language.

The students (totally about 500) are from 14 to 19 years old and can decide to learn up to six foreign languages. In addition to the obligatory languages they can choose Spanish, Russian and/or Slovenian. Besides that the students get an extensive instruction in economics, “Information and Office Management” as well as Applied Informatics.

Before introducing mobile learning we checked the technical equipment of the students by a preliminary survey (Sabitzer & Bischof, 2012).

About 75 % of the pupils own a smart phone with touchscreen, 40% of them with the operating system Android. The Internet is essential for mobile learning but fewer than 50 % of the students had contracts including more than 1 GB of data transfer and also only 55 % of the smartphones could connect with WI-FI. Before the workshop about 30 % already used it for school, mainly dictionaries.

3.2 The Introductory Workshop

The workshop about “Mobile Learning” was carried out in five groups of the voluntary subject “Lernen lernen” (Learning to learn), with about twelve students (14-16 years) each.

Each workshop lasted 90 minutes and was divided in two parts: The first part gave a short overview of the possibilities of mobile learning and in the second part the students had the possibility to try out the applications they were interested in.

In the overview we presented the following topics:

- General tools and applications, not only for mobile devices;
- Smartphone tools independent from the operating system, and
- Apps (applications) for the operating systems of Android and iOS (iPhone, iPad)

As general tools and applications, Google docs and Dropbox were introduced. These are two web-based file-storing systems for different purposes that allow jointly editing files and sharing them with others. In our school, all students have access to one common Google as well as one Dropbox account. This fosters collaborative learning independent from the classroom. In addition, the saved material can be used for other learning activities, not only on mobile devices.

After this introduction, the following smartphone tools independent from the operating system were presented:

- mp3-player for free audio-files in different languages, internet radio, etc.;
- voice recorder for registering the own learning contents e.g. vocabulary or dialogues;
- memo and sms, for taking notes and sharing them with others;
- video e.g. for presentations of different topics or dialogues for the development of an own language course, and
- websites (dictionaries, language courses like bbc.co.uk/languages etc.).

At the end, we presented some apps especially for the operating systems of Android and iOS (for iPhone) as well as for iPads, like language learning courses or the Leo-dictionary. Furthermore we showed different apps for flashcards, mindmaps and vocabulary trainers, which can certainly be used in all subject matters. The pupils seemed very interested and downloaded some apps immediately after the presentation.

In the second part of the workshop, the students formed small groups and tried out some different apps. All of them worked with their own smartphones and, additionally, each group could use one of the school's iPads.

After the workshop, the second questionnaire was given in order to evaluate the workshop itself and the presented applications. The results (details are described later) reveal that almost all students found the workshop useful and want to get a follow-up as soon as possible.

3.3 Mobile Language Learning

Besides the general workshop, the Spanish and Russian students had the possibility to put in practice what they had learned and to try out some new apps. Both languages are voluntary subjects of each two lessons per week and are held by the same teacher (one of the authors). These lessons have a special structure because of different reasons.

The first one is: they are bilingual. Spanish and Russian students (some of them learn both languages) study in the same classroom and the teacher permanently switches between the two languages. These groups are heterogeneous because the lessons are open for all students of the school. So language beginners learn together with advanced students, and, in both languages, all levels of the European Language Framework from A1 up to B2/C1 are represented.

These conditions cannot be managed by traditional teaching methods. The lessons require mainly self-organized learning with free work phases on a rotating basis. While Spanish learning students work on their own, supported on the one hand by advanced students and on the other hand by computers or mobile devices, the teacher can work with the Russian learning students and vice versa.

Another difficulty is the very dense timetable of the students. Sometimes they cannot attend the Spanish/Russian lessons because of other parallel events or courses at school (or because they have too many other things to learn), so it is necessary to integrate open and distance learning in both subjects. The use of the school‘s iPads and the pupils‘ own mobile phones allowed to implement some new and motivating learning tools that were presented in the workshop described above.

The Spanish/Russian lessons after the workshop were labor-intensive, but also fun. The students were highly motivated to try and use all the new applications they got to know in the workshop.

They worked in small groups, divided according to language and language level and started with free courses on the iPad. They tried the following three courses, available for Spanish as well as for Russian:

- 50languages, a free app for different mobile devices and operating systems, based on the corresponding online-courses with audio (Book2).
- Busuu, a language learning community for different languages, that offers some free lessons for each language level from A1 up to B2 as well as a tourist course (Busuu).
- Babbel, a multimedia language course, available online or via an app, that allows also to record the students' voice and to evaluate their pronunciation. (Babbel)

Based on these courses and using different multilingual dictionaries and verb conjugators on their own smartphones they wrote vocabulary lists and created mind-maps for some topics like animals, food, or time expressions. For the mind-maps they used the free apps Thinking Space (Android smartphones) and Simple Mind+ (iPad).

The vocabulary lists were typed in a Google table for two reasons: First, the school has one Google account where all pupils have the permission to save documents for learning. So they can work together on the same documents, independent from the classroom, and share their own work with others who are interested in.

The second reason is that these Google tables are the basis for two free learning apps for Android smartphones: Flashcards and a vocabulary trainer. Both apps work in the same way: the student selects one of the tables saved in Google (they are all listed in the app) and loads it on the phone. Once downloaded, the apps also work off-line without connection to the web.

Besides the different learning apps, the pupils enjoyed also the work with iPad videos. Some volunteers among the language beginners presented themselves in videos as a part of a digital curriculum vitae.

Observing the students‘ behavior and activities in these lessons, it seems that mobile learning is worth to be fostered because it increases motivation and offers a lot of possibilities. If it can enhance the learning outcomes, too, will be the question of a further study.

3.4 App-Programming in Informatics

The last step of implementing mobile devices in our school was the project “App-Programming with the App-Inventor” (Stadtmann, 2013), carried out in a class of the 11th grade. The students had to create their own Smartphone Apps, which were tested and evaluated by younger pupils from a lower secondary partner-school. As none of the students had any programming knowledge the teachers decided to apply the App-Inventor from the MIT (Massachusetts Institute of Technology) (App-Inventor, 2013). With this software Apps for Android-devices can be created easily and without programming experiences. The code can be built out of predefined parts including some concepts of programming. So the students could get a first view of these concepts and, as preparation, learned how to format pictures so that they could be used in their Apps.

Like for every new tool and also for the App-Inventor an introduction for the students was necessary. This was accomplished by a short teacher presentation as well as some exercises and adequate solutions. After this short introduction phase the main part of the project started during which the students had to fulfill following steps:

- designing an own App,
- planning the working process,
- collecting or creating materials and
- using the App-Inventor to realize the Apps.

For both the students and the teachers it was a challenging situation because of missing previous knowledge. The students had to work a lot on their own and teachers tried to help and to overcome difficulties. At the end of the project each group had a running smartphone App and all of them were presented and evaluated in the “evaluation class”. For the younger pupils it was very exciting to test the Apps and they were fascinated that the older students could produce such Apps on their own. The vocational school students got a very positive feedback, which proved that it was worth the effort and they could be proud of their own self-made products. During this project they went through a shortened software engineering process resulting in a mobile Application they could use on their own smartphones (Stadtmann, 2013).

4 EVALUATION

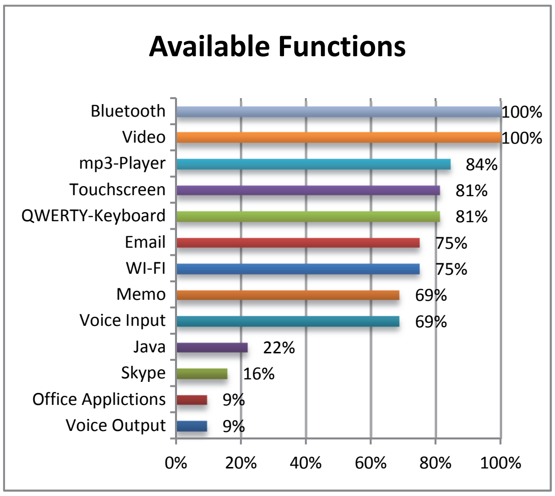

Figure 1: Functions available on mobile phones (n=32).

4.1 Introductory Workshop

The described workshop was evaluated by a questionnaire given to the participating students. 32 students completed the questionnaire.

Before the workshop most of the pupils rarely used the smartphones for learning and a third never used it. Another third of them sometimes used their mobile phones for school. Generally, the phones are well featured as shown in Figure 1. All students’ smartphones provide Bluetooth and Video and most of them use the mobile phone as mp3-Players (84%). As also voice input is mostly available (69%), the students' devices can perfectly support language lessons in the training of listening comprehension and speaking by following podcasts or creating own videos. E-Mail and Wireless LAN are available on 75% of the students' smartphones, which allows free online learning and/or search in the classroom by using the school WI-FI. The results show, that the implementation of mobile learning in different subjects is easily possible because of the students' equipment. Perhaps the school should provide some further mobile devices for students who don't have their own mobile phone or one providing only few functions.

After the workshop, the students were asked to evaluate how useful the different applications are for learning. They should give marks from very good (1) to insufficient (5).

A relatively clear decision of the students can be seen for the use of dictionaries, mind mapping, Office-Programs on the smartphone, Google docs, memos and notes, vocabulary trainer for Google docs, verbs conjugator and learning with own mp3-files. These applications were voted with very good or good by 50% or more students. The other applications are mostly assessed to be satisfactory. Table 1 shows the applications ranked by the rate of satisfaction (evaluated as very good or good).

Table 1: Ranked applications (n=31) and percentage of very good and good evaluation.

Application	%
Verb conjugator	74%
Memo and notes	74%
Dictionary	71%
Google Docs	61%
Mindmapping	58%
Learning with mp3 (own records)	55%
Vokabularytrainer for Google Docs	55%
Learning with SMS	55%
Office Software	52%
Flashcards for Google Docs	48%
Create flashcards for languages	48%
Create flashcards for other subjects	48%
Learning with provided mp3	45%
Encyclopedia, atlas, reference books etc.	45%
Formulary	42%
Dropbox	23%

Another important question was, which applications the students already used before participating in the workshop. Some students used the smartphone-applications for learning already before the workshop. About 50% used memos and notes on the smartphone, but nobody used Office applications or Flashcards. The other functions were already used at least by a few of the students. Summarizing the results of the questionnaire as well as the informal feedback and the teachers' observation in the classroom it can be said that, among students, the acceptance of mobile learning and the level of contentment are high. Almost all students found the workshop useful and asked for a follow-up as soon as possible.

4.2 App-Programming

The evaluation of the project "App programming with the App Inventor" is still running, hence, at the moment only the feedback of the "programmers" - the students of the vocational school (eight girls) – is available. The most frequently mentioned answers to the three given questions are presented here (translated or summarized by the author):

1.) What did you like most in app programming?

- I liked to try out all the Apps.
- It was great that we could be creative and it was fun to fiddle about with the App Inventor. Further it was interesting to take a look at other Apps and to compare them with our own. It was interesting to see how much work it was to create our small Apps.
- I liked to choose the pictures and sentences by myself, so I could be very creative.
- The work with the App Inventor was difficult but I liked it very much to plan and create Apps self-reliantly.

2.) What didn't you like in app programming?

The students didn't like

- that some errors, e.g. closing an App, could not be fixed.
- that it took much time to adapt the apps and
- it was exhausting and a bit annoying to type in all correct as well as all wrong solutions.
- to put together all the needed parts in the App Inventor.

3.) Did you have problems in programming?

- It was not possible to close the Apps.
- It was easy to generate the Apps but it was complicated to put together all the steps in the Block-Editor because we had to fade out all the English answer-possibilities.
- The buttons did not look like I wanted because they were on the wrong place. I was not able to make pictures appear and disappear at the right time. It was not possible

to create a break button and nobody could help me with this problem. Nothing worked as it should.

- It was difficult to program the buttons with the correct form and functioning.
- Our teacher could help me with every difficulty and all problems could be solved.

Further results - the evaluation of the apps by the students of the lower secondary school, interviews and teacher observations – will be presented in a further paper.

5 CONCLUSION AND OUTLOOK

Mobile learning is "cool" in the sense of motivating and fun. This is the core statement of the students' feedback in the questionnaires as well as in informal interviews. The results show, that the implementation of mobile learning in different subjects is easily possible because the students' smartphones are well featured. Perhaps the school should provide some more mobile devices for students who don't have their own phones or one providing only few functions. But generally the students like cooperating (COOL as COoperative Open Learning) and working in pairs, which is very reasonable in language lessons, where communication is essential, as well as in Informatics, where this cooperation can be compared to pair-programming, an effective software engineering method.

The evaluation of the workshop shows that in spite of the well-equipped students, only few know how to use the applications or which applications can help them to learn. The students should be trained to use their phones in a useful way because mobile learning brings dangers with it, too, like viruses, radiation, or distraction (Dabon, Martin & Starner, 2004). As long as mobile learning is applied only rarely, the positive effect of increased motivation may prevail the risks. But what happens when it is applied in every lesson? Perhaps the novelty effect would disappear and the motivation would decrease. This has to be verified in a further study.

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Use of Mobile Collaborative Tools for the Assessment of Out-of-Classroom Courses in Higher Education
Cloud Technologies Applied to the Monitoring of the Practicum

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Abstract: In this paper we propose the use of collaborative tools to enhance traditional e-learning platforms for university courses that are developed outside the school environment, as is the case of a Practicum or internship in a company or external institution. These courses have specific requirements with regard to monitoring, guidance and assessment of students, and we postulate that collaborative tools, usually implemented as cloud-based applications, combined with mobile technologies, today affordable to most students, constitute a suitable platform for implementing the assessment of this type of courses.

1 INTRODUCTION

Out-of-classroom learning plays an important role in education as a complement to formal learning at school. The philosophy of education known as constructivism (Kolb, 1984) describes how new knowledge based on real life experience is constructed and integrated into existing knowledge.

But out-of-classroom learning activities have special requirements with regard to student monitoring and guidance, due to the environment where this learning takes place, often far from the physical presence of the instructor. Today, technological solutions exist that facilitate online guidance and assessment of activities outside the classroom.

As part of a more general study aimed at facilitating graduates' college-to-work transition and seeking to improve labour insertion in the context of the European Higher Education Area (EHEA), in a previous work (Perramon et al., 2012) we have developed a monitoring system for university students taking a Practicum course, i. e. an internship or external practice stage in a company or institution, integrated into the Moodle e-learning platform. The learning activity in this case is not a single task that makes part of a broader subject, but usually a whole course in itself.

Our focus in this paper is on generalising the system to any type of out-of-classroom course, and on extending it to make use of mobile devices (phones, tablets) which are nowadays more and more ubiquitous among the population, and in particular among university students. A widely deployed technology that is suitable to our needs is collaborative software, usually implemented today as cloud-based applications.

2 OBJECTIVES OF THE STUDY

The main objective of this work is to study the usability of mobile technologies for the monitoring and assessment of out-of-classroom educational activities, with an especial attention to the Practicum.

To achieve this goal, we firstly study the characteristics of out-of-classroom learning in general, and the specific requirements for the Practicum where three different actors are involved: the student, the workplace tutor, and the academic tutor.

Next, we consider the currently available tools for performing the monitoring of these activities in a collaborative way. We focus on those which provide ubiquitous access by means of mobile technologies. We then analyse how to integrate these tools into the learning management systems that provide support for the assessment of the students' activities, and specifically the Practicum in our case. Finally, we discuss some advantages and disadvantages of the use of these technologies and we draw some conclusions.

The initial hypothesis of this study is that the combination of collaborative tools and mobile technologies provide an appropriate framework for the development of the monitoring system that satisfies the requirements of the Practicum and of out-of-classroom education in general. This appropriateness can be confirmed if the advantages of mobile collaborative systems overcome any possible disadvantages.

The methodology of this work is based on the analysis of the different tools and their capabilities in order to assess their usability for our purposes. The outcome is a proposal of the work to be developed for implementing the monitoring of the Practicum through mobile collaborative tools.

3 OUT-OF-CLASSROOM LEARNING

In general, "education outside the classroom" usually refers to any school learning that does not take place in a class of students with a teacher (Neill, 2008). In our case, we focus on courses in higher education that are developed completely out of the campus environment. Examples of this type of learning activities include research projects, fieldwork and, specifically, the Practicum in university degrees. In the context of the work presented here, we understand by Practicum a course intended to make students put in practise the theory they have learnt, to be developed typically as an internship in the professional environment of a welcoming institution, i. e. a company, a public administration, or any other kind of organisation. The benefits of the Practicum in the learning process have been described in different models (Jaques et al., 1993), and in particular in Kolb's (1984) "experiential learning", in line with the constructivist theory.

Several aspects of the Practicum make it singular. For the purpose of our work the interesting point is that, unlike classical courses where a teacher interacts with a group of students (one-to-many interaction), in the Practicum there is usually a triangular interaction between three actors: the student, the academic tutor or teacher, and the external tutor or person in the company or external institution who is in charge of the student during his or her internship. Each of the three actors interacts individually with the other two: the student with both tutors for consultation and guidance (each tutor in their respective scope, either the university or the workplace), and the tutors with each other for the assessment and monitoring of the student's work. In turn, each of the vertices of this triangle can be manifold: the internship may be taken by a team of two or more students working in collaboration, the academic supervision may be carried out collegiately by a tutor responsible for all internships in a degree and a tutor directly in charge of the student, and there may be several supervisors at the workplace, typically a senior and a junior supervisor, the latter providing more day-to-day guidance to the student's activities. Our proposal focuses on collaborative tools for student monitoring, but we could also introduce in this proposal a module for collaborative evaluation (Rodríguez-Campos, 2012).

Out-of-class activities can take place in very diverse environments, such as an office, a workshop, or maybe even in the open air. This raises the need for proper monitoring and student guidance, suitable to the context where the activity is developed. Given the peculiarity of the triangular relationship between participants, we consider collaborative tools accessible from mobile devices an appropriate solution for the monitoring of the Practicum.

In its simplest form, the interaction between the three actors can be regarded as an instance of cooperative editing of a document. Such a document, once finalised, could be the student's final report of their activity during the internship, to be submitted for approval in order to assess their achievements in the Practicum course. But during its preparation, this document can be a container for the periodic progress reports that the student has to elaborate, for the student's enquiries to the tutors asking for advice and the corresponding responses, for the interactions between both tutors regarding their observations on the student's progress, etc. Most collaborative tools provide some form of cooperative editing of documents that can be used in this way, but some of them also incorporate more advanced functionalities to facilitate this type of interactions.

4 COLLABORATIVE TOOLS

4.1 Basic Characteristics

Collaborative software, also called groupware, provides the foundations for computer-supported cooperative work or CSCW (Carstensen and Schmidt, 1999). These tools facilitate the cooperation among several users to fulfil a given task, by means of a common information space. This space can be used to share documents, messages, etc. in order to achieve the joint goals. In addition to this, project management tools or projectware, which form a subset of collaborative software, cope with task interdependencies in order to coordinate the various activities making up the project.

Different architectural models have been used for implementing collaborative software. The two main models are the classical client-server architecture, where each user runs a specific client application to access the collaborative space, and the web-based architecture, where the role of the client is played by a general-purpose web browser. This latter model has evolved to the cloud paradigm, whereby all the necessary resources, including applications and data, reside in a network of virtual servers (National Institute of Standards and Technology, 2011), and is rapidly becoming more and more widespread.

One of the most popular collaborative tools today is Google Apps (Google Inc., nd), based on cloud technology, and encompassing applications like joint editing of documents, presentations and spreadsheets, polls and surveys, forums, virtual meetings, hangouts, etc. Google Drive is the specific application within Google Apps to manage the storage and sharing of such resources. Another collaborative tool is Zoho (Zoho Corp., 2013), an office suite that comprises a number of components, grouped into business applications, productivity applications, and collaboration applications. The latter include Zoho Chat, Zoho Docs, Zoho Projects, etc. The Yammer service (Yammer Inc., 2014) is another example of a tool that can be used in a corporative environment for communication between its members. It is usually cited as an "enterprise social network", but it can be used in scenarios other than businesses. More recently, Asana (Asana, nd) has been developed as a teamwork tool for managing conversations and tasks in a more flexible way than simple e-mail exchange. As of today, there are dozens of different collaborative tools available, and their characteristics have been compared in many studies, e. g. Reixa et al. (2012), Drăghici et al. (2013), etc.

Like many others, Google Apps, Zoho and Asana are online services following the "software as a service" (SaaS) model. In these systems, all data (documents, calendars, conversations, etc.) and the application itself do not reside in the user's computer or device but in the server or servers supplied by the service provider, i. e. in "the cloud". The case of Yammer, although the server-side application is more characteristic of a social network, can also be included in this category.

The four examples of collaborative tools mentioned above are available for free, under certain conditions for personal projects or small groups, or for a monthly or yearly fee for larger professional teams. More commercial solutions also exist, but at present we focus on tools with basic functionality that can be used at no charge in an academic institution. An example of a commercial tool is Trunity (Trunity Holdings Inc., 2013).

4.2 Mobile Access

The ability to access the collaborative tools from a mobile device, i. e. a smartphone or tablet, is a positive factor for out-of-classroom courses given their externality.

Usually web-based applications can be accessed with most available web browsers, including those which are incorporated into mobile devices, i. e. smartphones and tablets. However the peculiarities of these devices (smaller display, touch-based input system) can complicate the user experience if the application is not specifically designed for them. Most applications intended to be used in mobile devices are therefore designed as mobile applications or "mobile apps" (or simply "apps").

This is the case for many of the collaborative tools described in the previous subsection. In particular, Google Drive as well as Asana and Zoho provide a mobile app version that can be downloaded to the user's device before accessing the corresponding tool.

This of course requires the user to be provided with such a mobile device, either a smartphone or a tablet. However today it is more and more common for students to have their own personal mobile device that they can use for training purposes at school. Actually, some academic institutions are introducing a BYOD policy (Bring Your Own Device) in their learning systems, a process that is not free from controversy, but it is out of the scope of this paper to debate this issue.

5 INTEGRATION WITH LEARNING MANAGEMENT SYSTEMS

External tools have been successfully integrated into learning management systems (LMS) using different methods, e. g. through the IMS Basic Learning Tools Interoperability (BLTI) standard (IMS Global Learning Consortium, 2010). If a LMS and an external tool both implement the BLTI interface, the tool can be integrated so that it is seen by users as though it was a

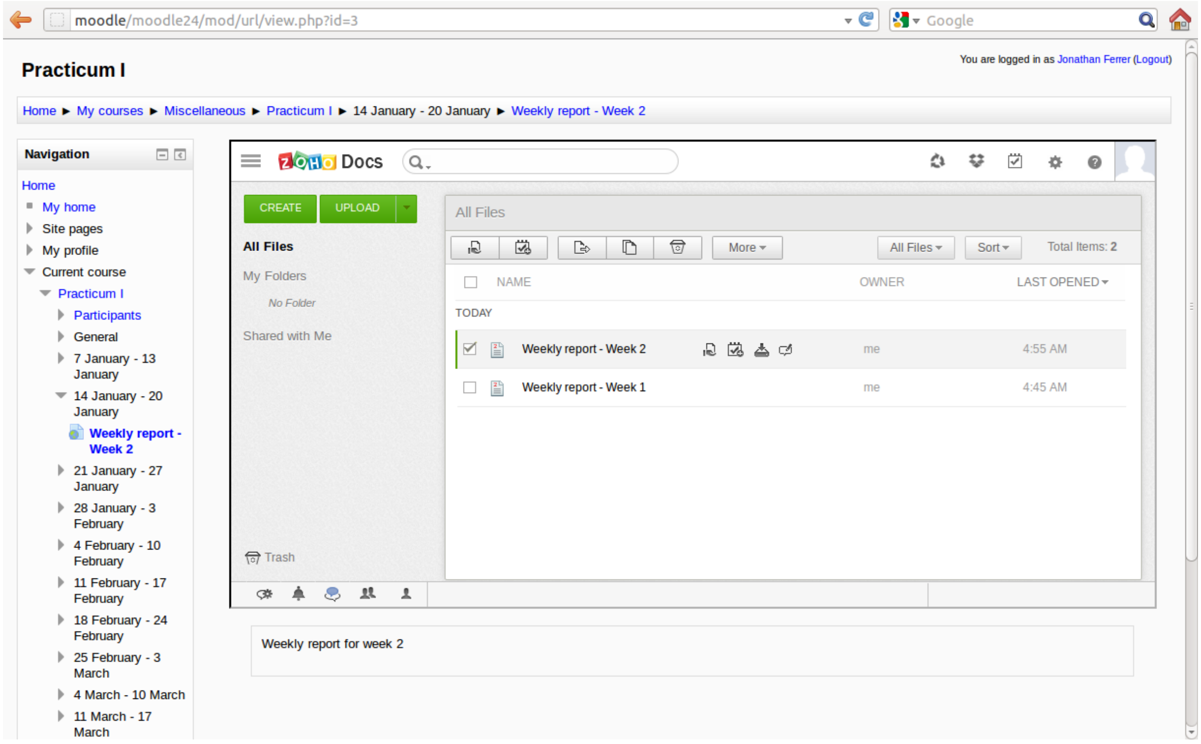

Figure 1: Example of the integration of Zoho Docs into Moodle as an embedded external link.

native tool of the LMS. This integration may imply, for example, that log-in to an external site is done automatically from data stored in the user's profile in the local LMS, following the "single sign-on" approach (SSO), without having to enter a new password.

One of the most popular LMS systems, the Moodle platform, incorporates support for BLTI since version 2.2. An example of a tool that makes use of this support for integrating Google Drive, and in particular Google Docs, into Moodle is Docs4Learning (Alier et al., 2012). On the other hand, Moodle provides a native module that allows the inclusion of wikis, which can be considered a basic form of collaborative tool, as part of the materials for a course. Also, the Moodle community has developed the Moodle-Google plugin (Moodle Documentation, 2011), available since version 2.1 of Moodle, that provides direct access to Google Apps, including Google Drive.

To the best of our knowledge, no implementations of the BLTI interface are available as of today for the other collaborative tools we mentioned above (Zoho, Yammer, Asana). Following up our proposal, we plan to evaluate the use of these tools within Moodle. If the results of these evaluations are satisfactory, we will implement the integration of the corresponding tool or tools in Moodle via BLTI or with a specific plugin.

As an interim solution for the evaluation of the tools, we can handle external objects in Moodle (e. g. a Zoho Docs shared document) as external resources, by inserting the links pointing to them. We have already applied this approach to the incorporation of Google Drive documents into an instance of an older version of Moodle, namely version 1.9, where it is not straightforward to install the Moodle-Google plugin (Perramon et al., 2012). Figure 1 shows an example of a Zoho Docs folder of documents shared between student and tutors, integrated as a resource within a Moodle course using the external link technique. This solution has the advantage of being simple to implement, although it does not provide full integration into Moodle. For example, it is necessary to login separately to Moodle and then to Zoho Docs, whereas a single sign-on solution would use the local user credentials in the LMS for transparently signing on to the external system. However, this arrangement is sufficient for our purposes of evaluating the use of the external collaborative tool.

Once the collaborative tool is integrated into the LMS, we can use it like any other component of the system. In particular, if the LMS provides an access method from mobile devices, it will also be possible to use it for accessing the collaborative tool. This is the case of Moodle, for which various mobile applications have been developed, including an official app (Moodle Documentation, 2014) and others with extended functionality, e. g. Moodbile (Piguillem et al., 2012). Through these apps it is then possible to use the collaborative tool embedded in Moodle from a smartphone or a tablet, as is the goal of our proposal.

6 ADVANTAGES AND DISADVANTAGES

The advantages of using collaborative tools have been mentioned in Section 4 above. In our case, the use of these tools in monitoring an out-of-classroom course such as the Practicum has the benefit of facilitating a smooth interaction between the three types of agents involved: the student, the academic tutor and the external tutor.

When considering the individual tools, there is not a single one that is clearly superior to the others. Google Apps is probably one of the most popular, but Zoho and Asana have also a large user base. Among their advantages, Asana is cited as having a friendly user interface, appropriate for non-technical users, while Zoho has been considered more robust and stable, and offers more functionality, although Google Apps is catching up, and probably even surpassing, as it is constantly evolving and upgrading in a move to anticipate users' needs.

We have also discussed in Section 4 the advantages of using mobile applications, and specifically in the case of out-of-classroom education in general and the Practicum in particular. Mobile applications are more and more widespread today, and apps are already available for Google Apps, Zoho, Asana, and also for Moodle and other learning management systems.

With regard to disadvantages of collaborative tools, especially those implemented as online services, most are derived from the perceived negative aspects of cloud computing technologies. A major concern is related to security and privacy issues. In the case of educational activities these issues are of relative importance, since the privacy is not as critical as in applications managing personal data or internal company information.

Another issue with cloud-based tools is closely related to one of the advantages mentioned above. The fact that application providers have an absolute control over the functionality offered by their services allows them to upgrade the online applications to adapt them to users' requirements. However, they sometimes do so without previous notice, and may force users to change usage habits when they would prefer to continue working with the previous version of the application with which they felt more comfortable.

As for mobile applications, their disadvantages come from the particular characteristics of the mobile devices: display size, touch-based input method, battery autonomy, network availability, etc. Obviously a smartphone or a tablet is not the ideal device for writing a long report about the student's activities, but it is appropriate for taking short notes in situ that could be otherwise forgotten when preparing the final report. Da Silva et al. (2013) have performed a study of the problems of mobile applications and web applications adapted to mobile access in the specific case of e-learning environments. They conclude that a better integration between devices and applications needs to be explored to enhance the user experience.

7 CONCLUSIONS AND FUTURE WORK

We have presented a proposal for the monitoring of a specific type of courses, in which all the learning takes place outside the classroom as it is the case in the Practicum or internship. This proposal is based on collaborative tools for managing progress reports, i. e. their preparation by students and their assessment by tutors, to be accessed from mobile devices given the external location of the learning process in these courses. We have shown that the technology is already available and the devices are in widespread use, and the implementation of our proposal is neither excessively complex nor expensive.

We plan to evaluate the use of different mobile collaborative tools inside a LMS platform, namely Moodle, and according to the results of this evaluation we will implement the integration of the selected tool, following simplicity and user friendliness criteria.

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